

**STORMWATER AND FLOOD MANAGEMENT UTILITY
BACKGROUND INFORMATION
TABLE OF CONTENTS**

I. GENERAL

- A. History**
- B. Legislative and Legal Foundation**
- C. General Administration**
- D. Boulder Valley Comprehensive Plan**
- E. Comprehensive Drainage Utility Master**
- F. Project Planning and Review Process**
- G. Public Involvement**
- H. Design and Construction Standards**
- I. Finance**
- J. Other Related Agencies, Programs and Plans**
- K. Information Management**
- L. Maintenance**

II. PROGRAM COMPONENTS

- A. Floodplain Mapping**
- B. Floodplain Regulations**
- C. Property Acquisition and Flood Mitigation**
- D. Flood Warning and Response**
- E. Flood Insurance and Public Education**
- F. Stormwater Drainage**
- G. Stormwater Quality**

STORMWATER AND FLOOD MANAGEMENT UTILITY BACKGROUND INFORMATION

February 7, 2003

I. GENERAL

A. History

In 1969, the City was impacted by a moderate flood which caused \$5 million in damages. The following decade marked the City's first serious efforts in flood control. Initial investigations focused on the then-traditional flood mitigation techniques, such as hard-lining stream channels and using concrete structural facilities to channelize stream flow. Following the 1969 flooding, the city adopted the first floodplain ordinance and the first drainageway master plan, referred to as the Wright-McLaughlin master plan. The floodplain ordinance, by requiring flood proofing of new buildings, ensured that new flooding problems would not be created. The master plan proposed improvements that would address future development and also remedy existing problems.

The city's first floodplain ordinance defined floodway and flood storage areas, and applied regulations to any land parcel that would be flooded during a 100-year flood.¹ Any area that might receive two or more feet of floodwater was subject to mandatory flood-proofing requirements. However, building permits for residences in floodways were still issued because proper floodplain delineations or maps had not yet been adopted and would not be adopted officially until 1975.

Also in 1969, Denver Adams, Arapahoe, Jefferson, Douglas and Boulder Counties joined, by vote of the Colorado General Assembly to form the Urban Drainage and Flood Control District (also referred to as the Urban Drainage District, or UDFCD). The UDFCD was given the authority to plan, design, construct, and operate drainage facilities throughout the five-county area. It was also charged with assisting in the implementation of early warning systems as well as helping municipalities within the district qualify for the National Flood Insurance Program. Floodplain management and flood control were topics of brisk discussion during the decade of the 1970s. From 1945 to 1973, the city had commissioned twenty flood studies, two-thirds of which recommended some kind of structural adjustment to Boulder Creek and its tributaries. Among the supporters of the structural approach to flood control was the United States Army Corps of Engineers (ACOE), which in 1970 formed the Corps of Engineers Citizens Committee on Environmental Planning (CECEP), presumably to foster community support for flood control through structural measures. The group evaluated a wide range of flood control strategies and

¹ The 100-year flood is defined as a flood having a once percent change of occurring in any year (BRC Title 9, Chapter 9, Section 9-2(29)).

determined that two approaches - channel enlargement and levee floodwalls or floodways - were economically justified.

During 1971, a radar installation at Limon, Colorado began operating. This system allowed for the issuance of more accurate weather information than had been available up to that time, setting the stage for the development of an advance flood warning system.

The ACOE and UDFCD published a "Special Flood Hazard Information Report" in 1972. This document formed the basis for the city's participation in the federally sponsored Flood Insurance Program. The report also described smaller than 100-year, regional floods which posed danger to residents and properties.

The CECEP continued to meet regularly during the 1970s and gradually turned away from structural solutions to flood control in favor of activities that did not require the building of walls, berms and dikes or the excavation and cementing of creek channels. In May 1977, it submitted an eleven-point plan concentrating on non-structural solutions to flood management. It also recommended the replacement of a number of Boulder Creek bridges which would significantly impede flows in the event of a flood.

On August 21, 1973, the City Council adopted an ordinance which created the storm drainage and flood control utility and also approved the first drainage master plan. This measure created a separate utility, segregated funds for drainage and flood control, and provided for the collection of a service charge to generate local funding. In order to collect the utility fees, a fair and equitable method of assessment was needed, requiring the physical inspection of more than 13,000 buildings within and outside of the 100-year floodplain. The survey information was used to develop a runoff coefficient expressing the amount of water per square foot which would run off a property as opposed to being absorbed or retained on the land. The coefficient was used to calculate fees to be paid by non-residential property owners. Residences were charged a flat rate based on lot size.

In the following years, additional modifications to the city's flood control and management programs and ordinances followed. Among these were:

- \$ Development of floodway and floodplain maps in 1974 and revision of these maps in 1983;
- \$ In 1975, adoption of a definition of a floodway as an area where water velocities are two feet per second or greater, where depths are two feet or greater, and where a one hundred percent development of the flood storage area would not create a rise of more than one-half foot;
- \$ 1975 version of the floodplain regulations which eliminated the issuance of permits for dwellings in the floodway;
- \$ Participation in the National Flood Insurance Program (NFIP) under the direction of the FEMA, beginning in 1975;
- \$ Completion of an early flood warning study in July 1977;
- \$ In 1978, adoption of a non-containment policy for Boulder Creek, and;

\$ Completion of an early warning system for Boulder and South Boulder Creeks involving both City and County personnel by the mid-1980s.

In 1986, City Council adopted the Greenhorne-O'Mara Phase A Tributary Drainageway Master Plan. This plan represented a reasoned balance between 100-year and lesser improvements based on life-safety and cost-benefit analyses. In addition, it identified environmental and aesthetic assets of each drainageway under consideration. For the most part, 100-year channel improvements were not the preferred alternatives identified in this study.

Greenhorne-O'Mara also completed flood hazard delineation studies for South Boulder Creek (1986) and Boulder and adjacent county drainages (1987).

In 1986, the Water Resources Consultants "Storm Sewer Collection System Master Plan" was adopted. This plan identified the system of inlets and storm sewers needed to convey drainage waters to the major drainageways.

The city's Comprehensive Drainage Utility Master Plan (CDUMP) was adopted in 1989. The CDUMP addressed flood utility problems and needs in the area of capital improvements, hazard mitigation and stormwater quality.

In 2002, City staff used current Geographic Information System data to determine the extent of potential flooding in Boulder. Table 1 and Table 2 summarize this information.

B. Legislative and Legal Foundation

The City is a municipal corporation duly organized and existing under the laws of the State of Colorado. In particular, the city is a home rule city and adopted a charter pursuant to Article XX of the Constitution of the State of Colorado by vote of the electorate on October 30, 1917.

The City has established and operates the Storm Sewer and Flood Management Utility pursuant to Title 11 Chapter 5 of the Boulder Revised Code. For direct access to the Code go to:

<http://www.ci.boulder.co.us/cao/brc/brc1981.html>.

As stated, the purpose of this code section is to protect the public health, safety, and welfare from damage from storm water runoff and floods by requiring that property owners in the city pay for a share of the cost of the drainage facilities necessary to manage such storm waters and floods.

The stated intent of the city council in enacting the code provisions are:

1. To promote public health, safety, and welfare by permitting the movement of emergency vehicles during flooding periods and minimizing flood losses and the inconvenience and damage resulting from uncontrolled and unplanned storm water runoff in the city;

2. To establish a master plan for storm water and flood management and its implementation, including without limitation, a coordinated program of creating upstream ponding or temporary detention of storm waters;
3. To establish a storm water and flood management utility to coordinate, design, construct, manage, operate, and maintain the storm water and flood management system;
4. To establish reasonable storm water and flood management fees based on the use of storm water and flood drainage facilities; and
5. To encourage and facilitate urban water resources management techniques, including without limitation, detention of storm water and floods, reduction of the need to construct storm sewers, reduction of pollution, and enhancement of the environment.

The city council finds and determines that the city has historically provided and will continue to provide storm water and flood management services by means of an enterprise, as that term is defined by Colorado law. The city council further declares its intent that the city's storm water and flood management utility enterprise be operated and maintained so as to exclude its activities from the application of Article X, Section 20 of the Colorado Constitution.

Title 11, Chapter 5 of the code also addresses the following topics:

- Definitions
- Master Drainage Plan
- Land Development
- Fees
- Use of Fees
- Plant Investment Fees
- Billing and Payment of Fees
- Certification of Unpaid Charges to County Assessor
- Leins
- Flood Channel Maintenance
- Utility Enterprise
- Revenue Bonds
- Governing Body
- Maintenance of Enterprise Status

C. General Administration

The City Charter provides for a Council/Manager form of government administration. The council chooses and appoints a city manager, a city attorney, a police magistrate, an auditor, as well as advisory boards and commissions. Council authorizes an audit of all financial accounts of the city is made annually and at such other times as Council deems necessary. The council considers all recommendations by the city manager, and by any of the advisory commissions or

the city departments. For more information about the City go to:

<http://www.ci.boulder.co.us/>

Policy direction for the Storm Sewer and Flood Management Utility is set by the City Council, and the Storm Sewer and Flood Management Utility is administered by the City Manager. The Utilities Division of the Public Works Department directs the day to day operations of all City utilities, including the water and sanitary sewer utilities and the Storm Sewer and Flood Management Utility. Although the three utilities are each financially independent, all three are managed in an integrated fashion. For more information about the Public Works Department go to:

<http://www.ci.boulder.co.us/pwplan/>

A copy of the Public Works organization chart is presented as Figure 1.

D. Boulder Valley Comprehensive Plan

The city and Boulder County developed the Boulder Valley Comprehensive Plan (BVCP) to guide and accomplish a coordinated, adjusted and harmonious development of the County, which, in accordance with present and future needs and resources, will best promote the health, safety, morals, order, convenience, prosperity and general welfare of the inhabitants. It is also intended to promote efficiency and economy in the process of development, including distribution of the population and land uses such as urbanization, trade, industry, habitation, recreation, agriculture and forestry to improve overall quality of life within the Boulder Valley and reduce waste of physical, financial and human resources which result from either excessive congestion or excessive scattering of population. The BVCP includes the area bounded by the mountains on the west, Davidson Mesa and Coal Creek on the southeast, the county line on the south, Gunbarrel Hill on the northeast, and the ridge between Mesa Reservoir and Boulder Reservoir and the area west of Left Hand Valley Reservoir on the north. For more information about the BVCP go to:

<http://www.ci.boulder.co.us/planning/bvcp/>

A basic premise of the BVCP is that adequate urban facilities and services are prerequisite for new urban development and that within the Boulder Valley the city is the provider of choice for urban services. On the basis of that premise, service standards are set as minimum requirements or thresholds for facilities and services that must be delivered to existing or new urban development to be considered adequate. Flood control and drainage is identified as an urban service which must meet the adopted urban service standards. The adopted service standards for flood control and drainage were developed according to five general criteria. The service standards are:

Responsiveness to Public Objectives

- Have personnel on call 24 hours per day for flood control and drainage emergencies.

Sufficiency and Dependability of Financing

- Have revenue sources which are guaranteed so that revenues are available for flood control and drainage related projects, materials, equipment, facilities and personnel.
- Be organized to request and receive Urban Drainage and Flood Control District, state, and federal funds, if available, for projects, facilities and equipment.

Operational Effectiveness

- Use annual budget for personnel, equipment, projects, facilities, and materials.
- Meet standards as exemplified by the UDFCD.
- Adopt regulations consistent with the FEMA.
- Meet the following flood control and drainage standards for new development:
- Runoff analysis shall be based upon proposed land use and shall take into consideration all contributing runoff from areas outside the study area.
- Storm runoff shall be determined by the Rational Method or the Colorado Urban Hydrograph Procedure.
- All local collection systems shall be designed to transport the following storm frequencies:
 - Single Family Residential - two (2) year storm
 - All other areas - five (5) year storm

The major drainageway system shall be designed to transport the 100-year event or a modified standard in an approved plan.

- Storm runoff quantity greater than the historical amount shall not be discharged into irrigation ditches without the approval of the flood regulatory authority or the appropriate irrigation ditch company.
- The type of pipe to be installed shall be determined by the flood regulatory authority, and shall be based upon flows, site conditions, and maintenance requirements.
- All new urban development in the Boulder Service Area, which shall be annexed, shall be required to meet the intent of the adopted City of Boulder floodplain regulations.
- Erosion and sedimentation control shall be exercised.
- Detention storage requirements will be reviewed by the flood regulatory authority.

Proficiency of Personnel

- All flood control maintenance crews shall be staffed by personnel trained and capable of operating the equipment necessary to maintain the flood control and drainage system.

Location and Adequacy of Equipment and Facilities

- Provide essential equipment and vehicles for flood control and storm sewer maintenance activities.

The BVCP was last updated in September 2001. Specific policies which pertain to the Utility are:

Policy 2.26 Urban Open Lands

Open lands within the fabric of the city provide recreational opportunities and density relief from the confines of the city as well as protection of the environmental quality of the urban environment. The city will promote and maintain an urban open lands system to serve the following functions: action and passive recreation, environmental protection, bike-pedestrian connections and enhancement of community character.

Policy 2.27 Boulder Creek and its Tributaries as Important Urban Design Features

Boulder Creek and its tributaries shall serve as unifying urban design features for the community. Within available appropriations, the city and county shall support the preservation or reclamation of the creek corridors for natural ecosystems, wildlife habitat and cultural resources; for recreation or trails; to provide flood management; to improve air and water quality; and to provide a contrast to urban development. Trail development shall be sensitive to the ecology, terrain and privacy of adjacent residents and surroundings.

Policy 3.10 Utility Provision to Implement Community Goals

The City shall consider the importance of the other objectives of the Comprehensive Plan in the planning and operation of the water, wastewater and flood control/drainage utilities. These other objectives include in-stream flow maintenance, enhancement of recreational opportunities, water quality management, preservation of natural ecosystems, open space and irrigated agricultural land, and implementation of desired timing and location of growth patterns.

Policy 4.01 Incorporating Ecological Systems Into Planning

Planning and policy decisions in the Boulder Valley shall be approached through an ecosystem framework in which natural regions like airsheds and watersheds are incorporated into planning, and an appropriate relationship between the built environment and air, water and land quality is considered.

Policy 4.19 Protection of Water Quality

Water quality is a critical health, economic and aesthetic concern. The city and county shall protect, maintain and improve water quality within the Boulder Creek basin and Boulder Valley watersheds as a necessary component of existing ecosystems and as a critical resource for the human community. The city and county shall seek to establish comprehensive goals for water quality, to maintain full compliance with federal and state water quality standards, and to reduce point and non-point sources of pollutants. Special emphasis shall be placed on regional efforts such as watershed planning and protection.

Efforts shall be made to take an integrated approach to the protection of groundwater, surface water, and storm water and to plan for future needs.

Policy 4.20 Water Resource Planning

The city and county shall work together and with other governmental agencies to develop and implement appropriate water quality standards, water resource allocations, and water quality protection programs. Water resource planning efforts shall include such things as: water quality master planning, surface and ground water conservation, and evaluation of pollutant sources. The city shall integrate water quality into other planning processes such as air quality, transportation and land use planning. Land use patterns that reduce water pollution and promote water conservation shall be encouraged. Local development plans shall be reviewed for their impact on water quality.

Policy 4.22 Storm Water

The city and county shall protect the quality of its surface water, meet all state and federal regulations for storm water quality and evaluated additional voluntary standards as appropriate.

Policy 4.23 Minimum Flow Program

The city shall pursue expansion of the existing in-stream flow program consistent with applicable law and manage stream flows to protect riparian and aquatic ecosystems within the Boulder Creek watershed.

4.24 Groundwater

The city and county shall continue to evaluate aquifers, groundwater recharge and discharge areas, and sources of groundwater pollution within the Boulder Creek watersheds and formulate appropriate pollution and source protection programs. Impacts to groundwater shall be considered in land use planning, development review and public land management practices.

4.25 Pollution Control

The city and county shall seek to control both point and non-point sources of water through pollution prevention, improved land use configurations, wetland detention areas, standards to control degradation of streams and lakes caused by storm runoff in urban and rural areas, and control and monitoring of direct sources of discharge, including those of gravel extraction and wastewater treatment facilities.

Policy 4.27 Flood Management

The functional and aesthetic qualities of drainage courses and waterways shall be preserved and enhanced. A non-containment approach to flood management shall be

used on Boulder Creek. A generally non-structural approach to flood control that emphasizes a natural appearance shall be used on all major water courses and drainageways. In some cases a structural solution may be used, consistent with adopted master plans.

Policy 4.28 Drainage Utility Plans

The City shall prepare and maintain drainage utility plans that define maintenance needs, priorities for improvements, funding requirements, the character of necessary structural improvements, and water quality issues.

Policy 4.29 Protection of High Hazard Areas

The City shall prevent redevelopment of significantly flood-damaged properties in high hazard areas. The City shall prepare a plan for property acquisition of flood-damaged and undeveloped land in flood high hazard areas. Undeveloped flood high hazard areas will be retained in their natural state whenever possible. Compatible uses of riparian corridors, such as natural ecosystems, wildlife habitat, and wetlands shall be encouraged wherever appropriate. Trails or other open recreational facilities may be feasible in certain areas.

E. Comprehensive Drainage Utility Master Plan (CDUMP) - 1988

After the establishment of the Utility in 1973, a substantial amount of time and money was invested in stormwater and flood management planning. Drainage policies and plans were completed for Boulder Creek, its major tributaries, the Gunbarrel area, and the stormwater collection system. The city became an active member in the UDFCD and became a participant in the National Flood Insurance Program. The Environmental Protection Agency began preparing rules and policies for the issuance of stormwater discharge permits intended to reduce the environmental impacts of stormwater discharges on receiving waters. The city anticipated that new obligations would arise with the stormwater discharge permit rules.

The completion of the plans, each suggesting needed projects, and impending EPA rules emphasizing water quality led to the preparation of the original CDUMP. The main purposes of the master plan were to identify ways to reduce life-safety hazards and property damage and improve water quality. The principle means of addressing these purposes is through city regulation of use and construction within the area for which inundation could be expected during a 100-year flood.

The 1988 CDUMP addressed flood utility problems and needs in the area of capital improvements, hazard mitigation and stormwater quality. Recommendations were developed to deal with the following major problems:

- \$ Inadequate revenues for capital improvements identified in adopted master plans for the major drainageways and storm sewer collection systems;
- \$ Lack of a complete, fully integrated flood hazard mitigation program, and;

- \$ Lack of a stormwater quality program that assesses and mitigates stormwater impacts to Boulder Creek and its tributaries.

A Flood Hazard Mitigation Plan was developed as a part of the CDUMP. This plan identifies measures for flood control, property protection, emergency services and floodplain management. The CDUMP was developed concurrently with the city's Greenways Master Plan (GMP) so that these plans could be successfully integrated.

A primary goal of the original CDUMP was to identify and set priorities for construction projects in order to develop the CIP and required financing. Thirty-two projects were evaluated on the basis of costs and benefits achieved. Nine parameters were identified and selected for scoring each project. Each parameter was given a weight (varying from 1 to 3) to designate its relative importance. A rate of importance (varying from 1 to 10) was additionally applied to each project to indicate its ability to meet the intent of each parameter. The parameters and weights were determined based on input from consultants, city staff and the public.

A final score for each project was calculated by multiplying the weight of each parameter times the project's perceived importance. The weighted parameters consisted of:

1. Lesser total (construction cost) (weight' 1)
2. Lesser O&M Costs (weight' 1)
3. Greater total benefit (weight' 2)
4. Increased public safety (weight' 3)
5. Response to citizen concerns (weight' 2)
6. Enhanced or preserved environment (weight' 2)
7. Enhanced community services and/or aesthetics (weight' 2)
8. Opportunity for economic growth (weight' 1)
9. Ease of project implementation (weight' 1)

Using this formula, the highest possible project score is 150. Actual project scores ranged from a high of 106 for Goose Creek from 28th Street to Folsom, to a low of 60 for improvements in the Gunbarrel area.

F. Project Planning and Review Process

All City capital improvement projects are subject to the Project Planning and Approval Process (PPAP). The Project Planning and Approval Process (PPAP) is the process for the review and approval of city master plans and public capital improvement projects in Boulder. The PPAP Handbook describes, in detail, the procedures for each phase in the review and approval of major city projects

The PPAP was originally developed and approved in 1992. Since that time, several issues with the review of master plans and capital projects prompted revisions to the process. In 2001, the City Council Environmental Sustainability Task Force listed improvements to the capital project planning and approval process as one of its areas of focus. The primary issue identified by task force members was that multiple city goals were not always effectively balanced in the early

stages of planning major capital improvement projects. The purpose of the update to the PPAP was to:

- assure that city projects balance Boulder Valley Comprehensive Plan (BVCP) goals to the best extent possible;
- assure that city projects meet City Pace goals;
- improve interdepartmental communication and coordination;
- improve early coordination and public input on projects prior to final design and construction; and
- assure consistency between public and private development projects.

The revised PPAP emphasizes up-front review of city projects at the conceptual planning phases; improving interdepartmental coordination and early assessment of potential impacts. For more information about the PPAP go to:

<http://intraweb.ci.boulder.co.us/buildingservices/reports/pdfs/draft.pdf>

The Community and Environmental Assessment Process (CEAP) is a formal review process to consider the impacts of public development projects. The CEAP was instituted by City Council in 1987 and is referenced in the Boulder Revised Code (B.R.C. Section 2-1, Appendix IX, Procedure in Handling Major Capital Improvement Projects).

The purpose of the CEAP is to assess potential impacts of conceptual project alternatives in order to inform the selection and refinement of a preferred alternative. The CEAP provides the opportunity to balance multiple community goals in the design of a capital project by assessing a project against the policies outlined in the BVCP and departmental master plans. The CEAP allows “fatal flaws” inherent in the concept design of a project to be discovered, thereby suggesting elimination of certain alternatives.

Projects that will require the CEAP review are identified during the annual CIP and budget process. A department first suggests projects that will need to follow the CEAP with their CIP and budget submittal to the PPAP Coordinator. The Project Coordination Group reviews all projects listed in the annual Capital Improvement Program and identifies the appropriate review and approval process for each project. The list is then reviewed by the Planning Board and adopted by the City Council with the budget.

G. Public Involvement

1. Water Resource Advisory Board

The Water Resources Advisory Board (WRAB) is the designated advisory board for storm water and flood management utility issues. Responsibilities include; 1) review all environmental assessments and capital improvements conducted or proposed by the utilities division; 2) review, monitor, and propose changes to the city's raw water, treated water, wastewater and flood control master plans; 3) review and provide recommendations to the city manager concerning policy issues on operating programs, including, without limitation, water conservation, water treatment

plant residuals, wastewater treatment plant biosolids disposal, and water quality. For more information about the WRAB go to:

<http://www.ci.boulder.co.us/publicworks/depts/utilities/wrab/wrab.html>

2. Independent Review Panel

The Independent Review Panel (IRP) was appointed by City Council in 2000 to provide community oversight of floodplain master planning efforts for Fourmile Canyon Creek. Following the success of this effort, several members were asked to review South Boulder Creek planning efforts and the IRP has also committed to participating in the Utility Master Plan update. IRP members contributing to the floodplain policy discussion include Dr. Gilbert White, Mary Fran Myers, Ken Wright, Brian Hyde and Rich Madole. Bill Bradley and Jonathan Friedman have also supported the IRP on other projects. The IRP outlined the following guiding principals for floodplain management:

- The benefits and costs of all floodplain functions should be considered in solutions to flood problems including flood conveyance, riparian habitat, open space and aesthetics, and recreation.
- Flood issues should be addressed from the perspective of the entire contributing watershed, and problem solving should be done on an overall basis for various portions of one large floodplain, recognizing that different reaches may deserve different action.
- A variety of floodplain management tools should be used to address flooding problems, and assessing the effectiveness of these tools should be done on individual buildings and properties rather than plans solely for entire reaches.
- Consideration should be given to the effects of upstream land use on stream flows and potential measures for downstream areas.
- Actions to reduce flood losses must consider natural and beneficial functions.
- A full range of action for individual reaches and buildings for floods up to 500-year frequency be reviewed.

Other specific policy recommendations presented by the IRP include using the 500-year frequency for flood mitigation and emergency planning, providing data for multiple storm depths (10, 50, 100 and 500-year events), addressing hydraulic bottlenecks (such as bridges and culverts), evaluating the public benefits that might accrue from natural floodplains, protecting critical facilities to 500-year levels, flood proofing individual structures, removing high risk structures, specific flood warning and evacuation plans, and managing upstream watershed conditions.

3. Citizen Advisory Group

The Citizen Advisors Group (CAG) was convened in 2001. It is comprised of citizens concerned about floodplain management policies that would be applied to the South Boulder Creek planning efforts. Over 30 citizens participated in the CAG and developed the following

floodplain policy recommendations that may apply to all citywide floodplain management activities:

- Ensure thorough public input on all floodplain management activities.
- Provide flood hazard education.
- Improve emergency notification and warning systems.
- Enable floodplain solutions that best represent community and citizen concerns.
- Do not force relocation of residents.
- Implement floodplain management measures: maintenance of creeks and storm drainage systems, site reviews to identify specific flood conditions, self-help flood protection, etc.
- Preserve natural riparian areas; avoid channelizing the creeks.
- Improve absorption and erosion control throughout watersheds.
- Develop a formal management processes to monitor activities in the floodplain and notify community members about changes which may impact them.

H. Design and Construction Standards

Title 11, Chapter 5 of the BRC establishes the development requirements related to storm water within the city of Boulder. The City Manager is charged with the development of a master drainage plan for the city to include all completed or proposed drainage facilities required to carry surface waters without overflow or discharge, as well as all drainageways and basins that directly or indirectly affect drainage within the city. BRC 11-5-4 requires that all development of land within the city must ensure adequate drainage and management of storm waters and floods falling on or flowing onto the property.

The City's Design and Construction Standards (DCS) regulate the design and construction of public infrastructure, improvements, and landscaping within the city's public rights-of-way and public easements. The DCS has undergone several updates in recent years including a complete rewrite in 1998 to replace the 1982 Design Criteria and Standard Specifications. Both the 1998 and 2000 updates have included significant changes in the area of storm water management. In 1998, a requirement for major storm detention was added to the previous minor storm requirement, the methodology for pond volume calculation was changed from a standard formula to a routed hydrograph method, and storm water quality requirements were introduced. Further refinements to storm water standards occurred in the 2000 update including the introduction of more detailed minimum standards for water quality best management practices. For more information about the DCS go to:

<http://www.ci.boulder.co.us/buildingservices/dcs/index.htm>

The DCS requirements for storm water management are primarily based on the UDFCD drainage criteria manuals. Some tables and charts have been adjusted to account for regional differences. Other references have also been used where they provide a clearer methodology or superior performance. Requirements for storm water quality best management practices refer almost entirely to the UDFCD manual.

Storm water issues related to land development and redevelopment are addressed through a variety of review processes coordinated by the Planning and Development Services workgroup. Most development and redevelopment projects are required to submit a Storm water Report and Plan prepared by a licensed professional engineer. The report and plan address how the project will maintain historic runoff rates and mitigate water quality impacts. In the case of projects with multi-step reviews, the level of detail progresses from conceptual, to preliminary, to final as other aspects of the project become more defined.

On-site detention storage is required for all developments other than individual single-family lots that are not part of a larger development. In order to obtain a building permit for parcels of land through which a natural drainageway flows, the owner must grant the city at no charge a permanent easement to construct, maintain, or reconstruct the channel along the drainageway and provide a financial guarantee for the construction of drainage facilities shown in the approved master plan.

I. Finance

The Storm Water and Flood Management Utility served a customer base of 22,137 properties as of December 31, 1997. Of this total, 4,072 accounts were inside a floodplain and 18,065 were outside a floodplain.

1. Fees and Rates

Storm water and flood management fees are reviewed periodically by staff and consultants to insure that adequate revenues are collected to meet all obligations of the Storm Water and Flood Management Utility. The City's storm water and flood management rates and charges are not currently subject to Public Utilities Commission review.

City utility rates are computed through an analysis of revenues compared to revenue requirements. The projection of revenue requirements is based upon an examination of historical costs incurred in providing utility service and reflected anticipated changes in the future level of costs. Increases in future costs are primarily due to replacements and additions to the system, growth and inflationary conditions. Projections of revenue are based on the estimated future number of customers to be served. Comparison of projected revenue requirements with projected revenue under existing rates measures the degree of adequacy of the overall level of current charges.

Rates and fees are annually assessed to fund activities of the Utility and to ensure that required reserves are maintained and debt service coverage requirements are met. Currently, the city strives to maintain a 20-25% operating reserve over a six-year planning period. Reserves are required for current bond issues and for the outstanding liability associated with employee leave benefits. In addition the Utility maintains a \$1,000,000 reserve available for post-flood property acquisitions.

Debt service coverage requirements are established as part of the Utility's bond covenants. On an annual basis the utility is required to generate net revenues before debt service, equal to 1.25 times its annual debt service requirements.

In addition to the city's annual review of rates and fees, a financial and rate consulting firm is hired approximately every five years to conduct a comprehensive rate and fee review. In May of 2001 Integrated Utilities Group, Inc., conducted such a study. The study recommended a revenue increase of 8.0% for the Utility. The recommendation was approved by city council as part of the 2002 budget process and rate changes became effective January 1, 2002.

a. Monthly User Fees

Monthly user fees were introduced when the Storm Water and Flood Management Utility was established in 1973. These fees were intended to cover operations, maintenance and replacements costs of the existing system and construction of new storm drainage and flood management facilities. In the early years, since the total collected was not adequate to serve all these purposes, the revenues generated were reserved for new construction and General Fund revenues were used for routine maintenance. Boulder's storm water and flood management fee remained at the base rate of \$1.00 per month from 1973 through 1981. In 1982 and 1987 such fees were increased. With the adoption of CDUMP in 1989, the Utility initiated fee increases, raising the base rate from \$1.67 per month to \$3.00 per month in 1989 and to \$4.03 per month in 1990.

The storm water and flood management fee is a fixed monthly charge assessed to all properties inside the City limits except those with no impervious areas. The fee is based on the amount of runoff each property contributes to the overall flow. A base rate for single-family residential customers is established and, for all other customers, the fee is individually calculated. The formula for all commercial, industrial, multi-family and trailer park customers is constructed to be in proportion to the base rate assessed to single-family dwellings. The base fee for a 15,000 square foot lot increased from \$5.35 to \$5.70 on January 1, 2002.

The utility billing office carries out payment processing, billing, collections and customer service functions for all three City utilities. The staff supporting this effort includes one billing supervisor and three customer service representatives.

The meter operations staff reads approximately 1,400 water meters each day. The staff consists of one meter reader supervisor and eight meter service technicians. These meter readings are entered into the utility billing computer system on a daily basis, generating bills which are mailed on the following day. Each property receives one bill per month which includes water, sewer, and flood control charges.

b. Plant Investment Fees

In 1989, the City adopted a Storm Water and Flood Management Plant Investment Fee ("PIF") to assist in the funding of growth- or expansion-related facilities for the collection and conveyance

of storm water runoff. The PIF is a one-time charge assessed to new customers of the flood control utility to provide equitable allocation of costs between existing and new customers.

The PIF is calculated based on a “buy-in” methodology analyzing past capital investments of the utility. The historical or original cost of all utility’s assets is adjusted to replacement cost and then adjusted to reflect the age and condition of the assets. It is then further adjusted to deduct outstanding debt to determine the net equity value of the utility system. The value is then divided by the total estimated equivalent residential units to determine the base fee used in charging new customers entering the system.

From 1989 to 1996, the PIF was calculated in a manner similar to the nonresidential monthly user fees. In 1998, the PIF calculation was adjusted to more accurately reflect the wide range of residential development happening in the community. Whereas, prior to 1998, residential property paid a PIF based upon a sliding scale dependent only upon property size, now each residential property pays a PIF based upon both its calculated runoff coefficient and property size.

Plant investment fees (PIF) were also recalculated as part of the May 2001 rate and fee review. PIF are a one-time fee collected when a property is annexed, developed or redeveloped and requires access to (capacity from) the existing water, wastewater, or flood control infrastructures. The PIF were last reviewed in 1996 and are calculated based upon the new replacement value of the utility assets less depreciation. On January 1, 2002 the PIF base rate was revised from \$1,095 to \$1,582. The replacement value of the utility assets less depreciation from the report for major functional categories is:

- | | |
|----------------------|--------------|
| • Land/Easements | \$32,247,619 |
| • Storm Sewers | \$33,772,117 |
| • Major Drainageways | \$31,889,919 |

2. Budgeting

Annual operating budget proposals are drawn up by the first-line operating supervisors of each functional group in the utilities division. These proposals are reviewed and modified by successive levels of management within the division until a final proposal is approved by the Utilities Director. The water, sanitary sewer and storm water and flood management budgets are entirely independent, each rely on separate revenue sources and each maintain separate accounting entities.

The city currently implements a two-year budget process. The intent of the two-year approach is to simplify the overall budget process by providing an extended outlook and by emphasizing a multi-year strategy and financial plan for each fund. The two-year process allows for the longer-range goal projections. Budgets are also reviewed annually for any necessary revisions.

The Utilities Division budget is developed with the objective of providing quality and reliable water services involving drinking water, wastewater and flood control/drainage that meet regulatory requirements and community desires. The Utilities Division emphasizes efficient

management of fiscal and natural resources and the protection of human and environmental health.

The Capital Improvement Program (CIP) budget for the coming five years is a part of the Department of Public Works, Utilities Division CIP. The annual CIP process is coordinated by the city's Planning Department. The utilities division selects capital projects for inclusion in the CIP based on priorities identified in the appropriate master plans. The Planning Department reviews all departments CIP lists for consistency and accuracy and compiles the citywide CIP for Planning Board and City Council review. The CIP covers a 6-year time period and is updated annually.

The 2003-2008 CIP for the Storm Water and Flood Management Utility continues the emphasis in recent years on major drainageway planning and improvements, with efforts directed at Goose, South Boulder, Four Mile, Bear, and Wonderland Creeks. Significant funding for some of these projects is anticipated through the Urban Drainage and Flood Control District and future bond issues. Localized drainage improvements and storm sewer projects are proposed for Upper Goose Creek and the Boulder Valley Regional Center Redevelopment area.

The Flood Control Utility also contributes \$150,000 per year to the Tributary Greenways Program. The 2003-2008 CIP is shown in Table 3. This CIP will be reviewed and revised in the spring of 2003.

3. Revenue and Expenditures

Total 2001 revenues for the Storm Water and Flood Management Utility were approximately \$6,656,000. These revenues are derived from monthly user fees (55.0%); development fees (16.5%); intergovernmental reimbursements, primarily from the UDFCD (12.8%); interest earnings (8.0%); rents and leases (4.2%); transfers from other funds (3.0%) and miscellaneous other revenues (.5%).

Total expenditures for 2001 were approximately \$8,423,000. Expenditures consist of capital projects funded from 1998 bond proceeds (31.6%); capital projects (31.5%); operating costs (17.3%); debt payments (15.4%) and account transfers (4.2%). The 2003 fund financial for the Storm Water and Flood Management Utility is presented in Table 4.

A chronology of projects undertaken by the Storm Water and Flood Management Utility from 1990 through 2001 is shown in Table 5. Where possible, project costs have been shown for each project. Review of this table indicates the following major expense categories; Studies and Planning (5.4%); Property Acquisition (37.5%); Major Drainageway Improvements (48.8%); Storm Sewers (7.0%); and Miscellaneous (1.3%).

J. Other Related Agencies, Programs and Plans

The Storm Water and Flood Management Utility works with several other agencies, programs and plans. Among these are:

1. Urban Drainage and Flood Control District (UDFCD)

The Urban Drainage and Flood Control District (UDFCD) operates five programs: Master Planning, Design and Construction, Maintenance, Flood Plan Management, and the South Platte River. Boulder County is not levied the 0.1 mill earmarked specifically for the South Platte River Program and does not participate in that program. The four programs relevant to the City of Boulder are described below:

The Floodplain Management program was established to prevent new flood damage potential from being introduced into the 100-year floodplains while encouraging the utilization of non-structural methods of flood damage mitigation. The UDFCD works with local governments to assure that they remain in the National Flood Insurance Program; assists local governments with floodplain regulations' delineates flood hazard areas; and assists local governments in the development of flood warning plans and the installation and maintenance of flood detection networks. It funds a private meteorological service to provide daily forecasts of flood-producing events to local governments. It requires that drainage and flood control facilities constructed by, or approved for construction by, local governments must be approved by the District for those facilities to be eligible for assistance from the Maintenance Program. Eligibility for assistance is determined by the Floodplain Management Program.

The Master Planning Program provides up to 50 percent of study costs for master planning efforts requested by local governments and having a multi-jurisdictional dimension. The five major concentrations in the Master Planning Program are major drainageway master planning; outfall systems planning; drainage criteria; support of local government stormwater NPDES discharge permitting efforts, and; special projects, such as channel and structure design in special circumstances, benefit-cost analyses, and wetland issues.

The Design and Construction Program provides funds for master planned improvements which are requested, owned and maintained by local government. District funds must be matched by local governments. The District adopts a five-year capital improvement program each year which lists projects and District participation by county. From 1974 through 1998, the District expended \$91 million in design and construction, of which approximately \$9.2 million has been expended in the city of Boulder.

The Maintenance Program provides funding and assistance to local governments for routine, restoration and rehabilitation drainageway maintenance activities in accordance with expenditure priorities established by the UDFCD. UDFCD-owned facilities receive funding first, followed by UDFCD-funded projects, projects funded by others, unimproved urban drainageways, and unimproved rural drainageways. From its inception in 1981 through 1998, the UDFCD has spent over \$58 million on drainageway maintenance. Since 1983, the UDFCD has expended over \$3.2 million on maintenance projects within the city of Boulder.

For more information about the UDFCD go to:

<http://www.udfcd.org/>

2. Greenways Program

The city of Boulder Greenways System is comprised of a series of corridors along riparian areas including Boulder Creek and six of its tributaries, which provide an opportunity to integrate multiple-use objectives. These objectives are:

- Riparian, floodplain and wetland protection and restoration
- Water quality enhancement
- Stormwater drainage (flood mitigation)
- Alternative Transportation for pedestrians and bicycles
- Recreation
- Protection of cultural resources

For more information regarding the Greenways program go to:

<http://www.ci.boulder.co.us/publicworks/depts/utilities/projects/greenways/>

The City's Draft Greenways Master Plan (GMP) Update was released in August 2001. The Greenways Master Plan builds on policies outlined in several existing adopted plans and policies including the Boulder Valley Comprehensive Plan, the Comprehensive Drainage Utility Master Plan, the Transportation Master Plan, the Parks and Recreation Master Plan, the Open Space Charter and the North Boulder Subcommunity Plan. Greenways projects are designed and constructed in compliance with the City's floodplain regulations and wetlands protection regulations, and Clean Water Act Section 404 permits.

It is one of the basic goals of the Greenways program to integrate floodplain management techniques which preserve open space, protect existing vegetation, wetlands and wildlife habitat, and support recharge of ground water through interconnections with surface waters. In addition, water quality objectives of the Greenways program include identification of opportunities to improve water quality in the tributaries prior to their confluence with Boulder Creek. Therefore, Greenways projects may include stormwater drainage improvements as well as flood control and water quality enhancements.

Stormwater and flood management objectives are balanced with the competing and sometimes conflicting goals of transportation, recreation, preservation of natural ecosystems, and water quality management through the city's Greenways Program, which overlays Boulder Creek and its major tributaries within city limits. The Utility provides approximately one third of Greenways Program funding. These funds can be used for improvements providing or maintaining flood safety along streams, conveyance facilities including box culverts, water quality enhancements and habitat improvements.

3. City of Boulder Transportation Division

The Transportation Department and the Transportation Master Plan (TMP) acknowledge that trails and bikeways are an important planning consideration, which, when in keeping with other program goals, may be accommodated in or near creek corridors. In many cases, stream corridors can be creatively developed to function as efficient bicycle and pedestrian transportation systems while simultaneously functioning as storm drainage and flood channels, open space and wildlife corridors, and attractive recreation corridors. The Storm Water and Flood Management Utility, the Transportation Department and the Tributary Greenways Program frequently cooperate to achieve program goals and objectives in common areas. To access a more complete summary of the TMP go to:

<http://www.ci.boulder.co.us/publicworks/depts/transportation/tmp.html>

4. City of Boulder Parks and Recreation Department

The Parks and Recreation Department and the Parks and Recreation Master Plan recognize the community need for more undeveloped open land or natural parks within the city for quiet, passive recreation. Where park lands occur along the city's drainageways, the Storm Water and Flood Management Utility may cooperate with the Parks and Recreation Department and the Tributary Greenways Program to achieve open land/natural park objectives while promoting drainage and flood control objectives. To access a copy of the Parks and Recreation Master Plan go to:

http://www.ci.boulder.co.us/parks-recreation/about_p_r/master_plan.pdf

5. City of Boulder Open Space and Mountain Parks Department

The Open Space and Mountain Parks Department operates in accordance with City Charter provisions and missions, among which are to preserve and restore natural areas with associated unusual, spectacular, historically important, scientifically valuable or rare examples of native flora and fauna; preserve water resources in their natural or traditional state, including wildlife habitats or fragile ecosystems; promote utilization of program lands for passive recreational use; preserve agricultural land uses and land suitable for agricultural production and; use of lands to prevent encroachment on floodplains. The Open Space Department through area management planning provides guidance and direction for management of specific areas; develops a framework for evaluating and incorporating appropriate uses of Open Space; prepares inventories and analyses of resources; provides opportunities for public participation, and; coordinates resource management, protection and planning with other city departments and public and private landowners. For more information about the City's Open Space and Mountain Parks Department go to:

<http://www.ci.boulder.co.us/openspace/about.htm>

6. City of Boulder Long Range Planning Programs

The Department of Planning and Development Services Long Range Planning is responsible for city wide and subcommunity planning. For more information about these activities go to:

<http://www.ci.boulder.co.us/planning/longrange/longrange.html>

The North Boulder Subcommunity Plan pertains to one of nine subcommunities within the city. This plan includes specific goals, objectives and action plans including recommendations for channel improvements, wetland protection and enhancement, wildlife habitat, and water quality protection, restoration and enhancement along segments of Fourmile Canyon Creek and Wonderland Creek. The recommendations of the North Boulder Subcommunity Plan have been incorporated into the Fourmile and Wonderland Creeks master planning efforts. As additional subcommunity plans are developed, additional goals and objectives pertinent to the Storm Water and Flood Management Utility will be developed.

The Urban Open Lands Program and the Urban Open Lands Master Plan proposes a system of open places with the city which collectively provide opportunities to experience the natural environment, meet as a community and move through the city. Urban Open Lands weave together multi-functional, human-made and natural systems within the City to define a new urban design framework. Urban systems such as parks, schools, and major transportation corridors are linked to natural systems, creating a rich mosaic of interconnected undeveloped spaces. Creek corridors can provide a significant component to this system and provide the opportunity to further open land and wildlife corridor protection goals within the city, while providing for bicycle and pedestrian connections and enhancing the city's flood control system. BVCP policy 2.26 articulates this vision.

7. Wetlands Regulations

The city of Boulder has adopted a wetlands protection ordinance (BRC Title 9, Chapter 12) to preserve, protect and enhance wetlands by discouraging development activities in wetlands and adjacent areas. For more information about the wetland regulations go to:

<http://www.ci.boulder.co.us/cao/brc/9-12.html>

The ordinance establishes a goal of no-net-loss of wetland acreage and function by regulating activities in and around wetlands. These rules apply to all wetlands mapped within Boulder's city limits as well as all wetlands on city owned land, and all city activities affecting wetlands regardless of location. City wetlands permits are required for projects which affect wetlands and associated buffer zones surrounding wetlands.

Wetlands and surrounding buffer zones, which vary in size based upon the significance of the wetland, are referred to as "regulated areas". Any activity within a regulated area which reduces the extent of a wetland or reduces the degree to which a wetland performs any function requires a wetlands permit. However, maintenance of an existing public or private road, structure, or facility, including drainage facilities, water conveyance structures, dams, fences or trails, as well as any facility used to provide transportation, electric, gas, water, telephone, telegraph, telecommunications, or other services, are permissible, subject to the requirement of best management practices as identified in City Wetlands Protection Program Best Management

Practices (May 1995). The maintenance activities may not materially change or enlarge any existing facility, structure or road.

Wetland Permits

The city requires that a wetland permit be acquired for any construction activity within a wetland or wetland buffer. The City Manager, through the Public Works Department is responsible for review and approval or denial of the wetland permits and the development of conditions of approval where appropriate.

In order to obtain city wetlands permits, projects must minimize adverse impacts to a wetland and its functions and must not jeopardize the continued existence of habitat for plants, animals or other wildlife species listed by the federal government, State of Colorado, or in the BVCP as threatened, endangered, rare, special concern, of undetermined status, or critical. In addition, the project must be demonstrated to be in public interest in comparison to the anticipated effects. The permit may be conditioned to further reduce project impacts. A mitigation plan is typically required to provide restoration or creation of wetlands in order to offset losses resulting from the permitted activities.

Wetlands permit applications contain a description of the proposed activity; a discussion of why avoidance and less damaging alternatives have been rejected by the applicant; a site plan; locations and specifications for all proposed regulated activities and the associated impacts; descriptions and statements concerning proposed fill materials; and a referral list for property owners within 300 feet of the project and other interested parties. The Planning Board may call up wetlands permit applications within 14 days of the approval by City staff, and the City Council may call up Planning Board recommendations.

Many City projects are subject to two wetlands permitting processes. Section 404 of the Clean Water Act (33 U.S.C. 1344) prohibits the discharge of dredged or fill material into waters of the United States without a permit from the ACOE. Section 404 permitting requirements apply to all waters of the United States, including adjacent wetlands and tributaries to navigable waters of the United States. All projects which modify drainage channels and/or otherwise affect adjacent streamside vegetation generally require this type of permit. Many SWFMU projects can be addressed through ACOE “nationwide permits”, which authorize broad categories of projects such as maintenance, utility line backfill and bedding, etc. In applying for this type of permit, the city must describe its proposed project, describe project impacts, including effects to wetlands, and outline measures to be taken to avoid or reduce adverse effects to wetlands and to ensure full rehabilitation of disturbance following project completion. Where permanent loss of wetlands is unavoidable, restoration of nearby wetlands which have been damaged or degraded, at a rate exceeding the area of permanent loss, is generally required.

K. Information Management

Management of information is an important component of the city’s Storm Water and Flood Management Utility program. Since 1989 significant advances have been made in computerized information management techniques including Geographic Information Systems (GIS). The City

has taken significant steps in developing these systems. A list of GIS resources is presented in Exhibit A. To access GIS resources go to:

<http://intraweb.ci.boulder.co.us/buildingservices/gismap.html>

The city has numerous GIS datasets managed by Open Space and Information Resources. Other department-specific datasets are maintained throughout the city. These GIS datasets are primarily stored one of three formats, ESRI coverages, ESRI shapefiles, or AutoCADD drawings with accompanying Microsoft Access databases. The IT Department has recently implemented a spatial database using ESRI's SDE technology. It is anticipated that this database will function as a citywide GIS data repository for all departments. Although this will centralize data storage, updating and maintenance of the data will remain the responsibility of the appropriate department.

MapLink is a customized extension to ESRI's ArcView software. The goal of this extension is to provide city staff with an easy to use application for accessing GIS data. Additionally, MapLink automates more complex tasks such as buffering parcels, generating mailing labels and printing quality, to-scale maps.

a. Drainageway Information Management System (DIMS)

The current Boulder Drainageway Information Management System (DIMS) Project commenced in May 1999 and is a continuation of the 1997 DIMS pilot project on Bear Creek. The 1997 pilot project was an attempt to demonstrate the validity of showing drainageway facilities (e.g., improved channel segments, drop structures, bike path, erosion protection, etc.) on AutoCADD drawings utilizing the city's 1993 digital aerial mapping and linking those discrete mapping items to a Microsoft Access database. The pilot project was considered sufficiently successful to warrant an expansion of the effort to include the major drainageways within the Boulder corporate limits.

Field data collection was completed in 1999. This effort consisted of a complete walk-through of the drainageways (approximately 30 miles) to update the original 1995 facility inventory and condition assessment database to include any new construction and to verify the location and condition of existing facilities. The facility inventory, condition assessment database and AutoCADD maps showing the discrete facility locations were completed in 2000. City Utilities Project Management staff will update this information as changes to the drainage ways occur. The updated information will be used to track the progress of maintenance activities and will serve as a partial basis for valuing assets of the Utility for purposes of determining Plant Investment Fees.

b. Underground Facilities GIS Layer

The City's underground facilities geographic information system is comprised of utility infrastructure drawings that are maintained using Autodesk Map3 software with links to corresponding Microsoft Access 97 databases. A separate drawing is maintained for each of the

following utilities; water distribution, storm drainage, wastewater collection, and city owned telecommunications.

Utility drawings and their associated tabular databases have been converted to ESRI shape file format. Using ESRI shape files, non-GIS staff can display and query utility information using a low cost, easy to use GIS browser. Utility information can also be displayed with other city GIS data such as ownership parcels, buildings, floodplains and zoning.

Merrick and Co. delivered digital aerial photography covering the east half of Boulder County. Utilizing GIS software, the utility drawings can be superimposed on the aerial photography. This process has proven to be extremely valuable for drafting utility as-builts.

c. Property and Easement GIS Layer

The City relies on the Boulder County Assessor's Office to maintain the primary property data set including address, owner and physical information concerning the land and related development. In addition to this information, Merrick and Co. completed the citywide easement map project in 2000. Merrick captured plated easements from subdivision plats and legal easements from existing CAD basemaps into one GIS layer. PDS Information Resources staff completed quality control checks and will continue to update and maintain this information.

d. PlanLink Record System

PlanLink is a customized Microsoft Access database used to store and retrieve scanned As-Built and Planning documents. Related documents are organized and indexed into projects within the database. Descriptive information about each project is entered into the database. The document is then scanned and stored on a file server. Users query the project information in the database to find and retrieve relevant images.

L. Maintenance

The Storm Water and Flood Management Utility provides funding for both stormwater and flood channel maintenance activities. In 2002 there is approximately \$201,000 budgeted for maintenance of the flood carrying capacity of the creek channels within the city. The budget provides for 1.8 FTE, approximately \$103,000 in personnel costs and \$98,000 for non-personnel costs. Flood Utility staff remove sediment from channels, stabilize banks, and remove trees or tree limbs that have fallen into the creeks. Adjacent landowners are required to handle leaning trees or trees that have fallen away from the creek channel.

The UDFCD is responsible for maintaining and preserving floodways and floodplains in areas eligible for UDFCD maintenance and funded by the UDFCD. UDFCD maintenance is limited to facilities that are publicly owned or are in a public drainageway easement and are categorized into routine, restoration and rehabilitation projects. Routine maintenance consists of scheduled mowings and trash and debris pickup on major drainageways during the growing season. It may also include small revegetation efforts and limited weed control. Restoration projects address local erosion problems, existing structure repair, detention pond restoration, tree thinning,

removal of sediment deposits from flood control facilities and revegetation work. Rehabilitation projects are major reconstruction efforts that would be included as CIP projects in the city of Boulder.

The stormwater collection maintenance budget for 2002 is \$358,000. The Transportation fund also contributes \$153,000 for storm sewer maintenance activities. Combined these dollars fund 5.3 FTE, approximately \$285,000 in personnel costs and \$226,000 for nonpersonnel expenditures. The maintenance crews perform a wide range of activities for the purposes of flood control and drainage maintenance. Maintenance activities for 2001 included the cleaning of 1,729 catch basins; performing channel maintenance along 194,480 feet of drainageway; jetting 32,151 feet of storm sewer; rodding 9,419 feet of storm sewer; bucketing 13,289 feet of storm sewer; and completing video inspection of 225,619 feet of storm sewer. The latter has proven to be a very useful tool in determining storm sewer maintenance needs. In addition, the storm sewer and ditch maintenance crews continued an on-going cooperative effort with the city's Wetlands Coordinator to implement less disruptive maintenance practices in wetlands and other sensitive areas and insure compliance with best maintenance practices.

Maintenance crews are responsible for maintaining flood channels and the storm sewer system. Storm water collection is separate from the wastewater system, allowing storm water from streets and other paved areas to drain through a network of pipes directly to area creeks. In unpaved areas, overland flow from storms or excess irrigation may be collected through storm water drains or will naturally percolate through the soil, eventually reaching ground water. Utility Maintenance staff is responsible for maintaining the flood-carrying capacity of all the city's "greenways" channels, which primarily involves removing tree limbs and downed trees from obstructing the flow in the channels, removal of channel sediment, and bank stabilization.

Maintenance staff performs a formal inspection of all city-managed drainage ways once a year. Staff removes trash, sediment, and downed trees or tree limbs that might restrict or impede the water flow. Grass-lined drainage ways are usually mowed four times per season from the waterway to the top of the bank. Staff also responds on a complaint basis to all notifications of drainage way problems or concerns. Adjacent property owners are required to handle leaning trees or trees that have fallen away from the creek channel.

The City has an adopted "Greenways Master Plan" that provides guidelines for the development and maintenance of a series of corridors along riparian areas including Boulder Creek and six of its tributaries. The plan provides guidance on habitat protection, water quality enhancement, storm drainage and floodplain management, trails, recreation and cultural resources.

Maintenance crews perform video inspections as well as high pressure water jetting and rodding of the storm sewer system to keep the system functioning effectively. Root intrusion areas are identified and roots are removed mechanically. Manholes or catch basins exhibiting large amounts of material are cleaned using vacuum equipment.

The City is currently measuring all manhole elevations and the invert elevation of storm water manholes and putting this information into a graphic information system storm water plan.

M. Capital Improvement Program

The CIP covers a 6-year time period within which funding priorities are reflected in the staging and timing of projects. The primary factors considered in determining funding priorities for the Storm Water and Flood Management Utility are as follows:

- Property damage or safety hazard mitigation;
- Water quality and other environmental regulations;
- Worker health and safety;
- Opportunity to collaborate with other city projects, i.e., transportation;
- Potential for operation and maintenance cost savings, and;
- Accommodating new growth and development.

In accordance with city policy, the preparation of the annual CIP for the Storm Water and Flood Management Utility is coordinated by the Planning Department. The department selects capital projects for inclusion in the CIP based on priorities identified in the master plan. Project managers estimate the budgets for projects and determine CEAP requirements. The Public Works Department – Utilities Division submits project descriptions and justifications, cost/revenue estimates, an evaluation of relevant citywide and master plan goals to the Planning Department for inclusion in the CIP. The Utilities Division also requests a recommendation from the WRAB concerning the CIP for the benefit of the Planning Board and City Council.

The Planning Department reviews department CIP lists for consistency and accuracy. An interdepartmental staff team reviews the CIP for CEAP requirements. Suggestions are made to the department concerning CEAP requirements. The Planning Department compiles the citywide CIP for Planning Board and City Council review. The Planning Board conducts a CIP hearing and reviews the budget in terms of citywide project coordination, consistency with adopted master plans, balance among citywide goals and CEAP requirements.

Projects are planned and designed by city staff, in conjunction with appropriate outside agencies and/or consultants. Detailed planning and design efforts begin during the CEAP process for projects identified in the CIP for funding and construction. The design of each project is modified through the process based on public input, permit requirements and the development of more accurate, project-specific information.

Storm Water and Flood Management Utility Capital Improvement Program (CIP) expenditures have recently been prioritized based on the following criteria:

- Mitigation of life safety
- Public property damage mitigation
- Water quality and other environmental regulations
- Worker health and safety
- Opportunity to collaborate with other city projects, i.e., transportation
- Potential for operation and maintenance cost savings
- Accommodating new growth and development

II. PROGRAM COMPONENTS

City staff has identified major program components as follows:

Floodplain Management

The component focuses on major storm events and includes the following subjects:

- Floodplain Mapping
- Floodplain Regulations
- Property Acquisition and Flood Mitigation
- Flood Warning and Response
- Flood Insurance and Public Education

A Study Session on Floodplain Policies was presented to City Council on January 29, 2002. The study session provided Council with background information on local floodplain policies, an analysis of floodplain policy trends and philosophies, and staff-recommended floodplain policy objectives to update and adjust the Storm Water and Flood Management Utility Master Plan. Council members generally supported the recommended guiding principals outlined by staff that included:

1. “Preserve Floodplains” -
2. “Be Prepared for Floods”
3. “Help People Protect Themselves from Flood Hazards”
4. “Prevent Adverse Impacts and Unwise Uses in the Floodplain”
5. “Seek to Accommodate Floods, Not Control Them”

Stormwater Drainage

The component focuses on minor storm events, i.e. less than 10-year recurrence interval. The last stormwater collection system master plan was completed in 1984. Many of the study’s recommendations have not been implemented and will need to be reviewed to assess their current priority. Stormwater drainage issues include:

1. “Maintain and preserve existing and natural drainage systems”
2. “Reduce and manage developed runoff”
3. “Eliminate drainage problems and nuisances”

Stormwater Quality

During 1999 - 2002, Boulder’s Public Works staff has participated in a regional approach to stormwater quality planning through the WASH program (Watershed Approach to Stream Health). Boulder County Health Department has provided coordination for the program, with active participation by Boulder County, the cities of Boulder and Longmont and the towns of

Superior and Erie. The cities of Louisville and Lafayette have also expressed interest in the program.

A major factor in development of the WASH project is future compliance with the new federal stormwater regulations, which take effect in March 2003. These regulations require implementation of six programs to manage and improve stormwater runoff quality discharge from a city's stormwater system to surface waters. Boulder has an obligation to address stormwater quality issues under these regulations and is working in a collaborative fashion with other communities in the region to reduce pollutants to surface waters. The WASH project seeks to protect water quality through regulatory compliance and cooperative, regional management of stormwater issues. Stormwater quality issues include:

1. "Comply with Water Quality Regulations"
2. "Reduce the Amount of Runoff"
3. "Improve Quality of Runoff"
4. "Save our Streams"

A. Floodplain Mapping

Several agencies are involved in floodplain mapping as discussed below.

a. Federal Emergency Management Agency

The Federal Emergency Management Agency (FEMA) established standards for floodplain mapping studies as part of the National Flood Insurance Program (NFIP). The NFIP makes flood insurance available to property owners in participating communities adopting FEMA approved local floodplain studies, maps and regulations. FEMA approved floodplain studies and maps include the:

- Flood Insurance Study (FIS): The FIS develops flood-risk data for various areas of the community that will be used to establish actuarial flood insurance rates and to assist the community in its efforts to promote sound floodplain management. The FIS provides the technical reference for adopting detailed floodplain studies for area streams that are used to delineate the floodplain. The FIS includes detailed flood profiles and serves as the primary NFIP document for establishing floodplain elevations for use in determining flood risks, insurance premiums and floodplain restrictions. The current city of Boulder FIS is dated October 4, 2002.
- Flood Insurance Rate Map (FIRM): The FIRM is designed for flood insurance and floodplain management applications. For flood insurance, the FIRM designates flood insurance rate zones to assign premium rates for flood insurance policies. For floodplain management, the FIRM delineates 100- and 500-year floodplains, floodways, and the locations of selected cross sections used in the hydraulic analysis and local floodplain regulation. Current city of Boulder FIRM map panels are dated June 5, 1995, with an Index dated October 4, 2002.
- Letter of Map Revision (LOMR) and Map Amendment (LOMA)
LOMRs and LOMAs represent separate floodplain studies dealing with individual properties or limited stream segments that update the FIS and FIRM between periodic FEMA

publications of the FIS and FIRM.

Floodplain studies that may be approved by FEMA include federally funded studies, studies developed by state, city and regional public agencies, and technical studies generated by private interests as part of property annexation and land development efforts. Such studies may include entire stream reaches or limited stream sections depending on the nature and scope of a study.

The floodplain studies approved for the current FIS and FIRM were prepared by the Urban Drainage and Flood Control District, under their flood hazard area delineation program, and the city of Boulder Storm Water and Flood Management Utility.

b. Colorado Water Conservation Board

The Colorado Water Conservation Board (CWCB) is an agency of the Colorado State government. The CWCB Flood Protection Program is directed to review and approve statewide floodplain studies and designations prior to adoption by local governments. The CWCB is also responsible for the coordination of the NFIP in Colorado, and is to provide assistance to local communities in meeting NFIP requirements. These responsibilities can produce CWCB prepared or partnered floodplain studies for local adoption.

c. Urban Drainage and Flood Control District

The Urban Drainage and Flood Control District (UDFCD) is an independent agency established by the Colorado legislature to assist local governments in the Denver metropolitan area with multi-jurisdictional floodplain management and storm water drainage issues. The UDFCD is governed by a 17-member board of directors, of which 15 are locally elected officials, and is funded by property tax mill levies. The UDFCD Flood Management Program assists local governments in developing regulatory floodplain studies as part of their flood hazard area delineation program. The city of Boulder is a member of the UDFCD.

The Flood Hazard Area Delineation (FHAD) is a technical report used to identify flood prone areas within the jurisdiction of the UDFCD. Each report incorporates hydrologic and hydraulic analyses for specific drainage basins and major drainageways to guide local officials in planning the use and regulation of the 100-year floodplain. FHAD's are authorized and contracted through the UDFCD on behalf of participating local communities, and may involve local matching funds.

The FHAD includes area maps that delineate the 100-year floodplain and technical cross sections used to study the floodplain. The FHAD also includes tabular information to define the UDFCD floodway, using the half-foot rise criterion. The half-foot rise floodway is also used in local floodplain regulations to identify the city of Boulder conveyance zone. Additional background provided in the FHAD includes a basin description, flood history, related flood studies, hydrology and hydraulic determinations, and discussion of future floods.

A FHAD that has been accepted by the UDFCD and subsequently approved by the Colorado Water Conservation Board (CWCB) to designate flood hazard areas will be adopted by the city to regulate floodplain development, guide future drainageway improvements and plan flood

protection measures. An approved FHAD report, combined with other technical information developed as part of a study contract, will also be submitted to FEMA for incorporation into the FIS and FIRM under the NFIP.

Currently, three separate FHAD's are adopted for use in the city and have been incorporated by FEMA to publish the FIS and FIRMs for Boulder. Adopted local FHAD reports include:

- i. Boulder Creek Flood Hazard Area Delineation (Muller Engineering Company, Inc. January 1983): The Boulder Creek FHAD delineates the 100-year flood hazard along a 4.8-mile stretch of Boulder Creek from 55th Street to the mouth of Boulder Canyon. The report includes water surface profiles for the 10-, 50-, 100- and 500-year flood events. Three separate floodways were computed for the study, a one-foot rise (FEMA standard), half-foot rise (UDFCD standard), and combination half-foot rise, two-foot or greater depth, or two-foot per second or greater velocity (formerly the Boulder floodway standard). However, no floodway data was published in the adopted FHAD, pending publication at a later date following determination of the appropriate local standard. As a result, the FIS and FIRM approved by FEMA for Boulder Creek do not reflect a federally regulated floodway. A conveyance zone (half-foot rise standard) has since been adopted for local "floodway" regulation of Boulder Creek.
- ii. South Boulder Creek Flood Hazard Area Delineation (Greenhorne & O'Mara, Inc., July 1986): The South Boulder Creek FHAD delineates the 100-year floodplain along a 7.7-mile stretch of South Boulder Creek from the Burlington Northern Rail Road north of Arapahoe Avenue to the west end of Eldorado Springs, at the mouth of Eldorado Canyon. The report includes water surface profiles for the 10-, 50-, 100- and 500-year flood events and published floodway data for the one-foot rise and half-foot rise floodway criteria. However, the FIS and FIRM approved for South Boulder Creek based on the FHAD do not reflect a federally regulated floodway, with the exception of a single reach between Arapahoe Avenue and the Burlington Northern Rail Road. The city regulates the conveyance zone (half-foot rise floodway) along incorporated South Boulder Creek areas.
- iii. Flood Hazard Area Delineation, Boulder and Adjacent County Drainageways (Greenhorne & O'Mara, Inc., May 1987):

The Boulder and Adjacent County Drainageways FHAD delineates the 100-year floodplain along 26.8 miles of 11 separate streams within the city and Boulder County. Streams studied include:

Goose Creek
Gregory Canyon Creek
King's Gulch
Skunk Creek

Bear Canyon Creek
Bluebell Canyon Creek
Elmer's Two-mile Creek
Fourmile Canyon Creek

Sunshine Canyon Creek
Twomile Canyon Creek
Wonderland Creek

The report includes water surface profiles for the 10-year and 100-year flood events and

floodway data for the city's former floodway standard (half-foot rise, areas where depths exceed two feet, or where velocities exceed two feet per second). The FIS and FIRM approved for these streams based on the FHAD include a federally regulated floodway as reflected in the FHAD.

The city of Boulder FHAD reports are more than fifteen years old. No new FHAD studies have been adopted since 1987. These FHADs still provide the official delineation for most of the regulatory floodplains in Boulder, with the exception of several updated floodplain studies undertaken by the city.

d. City of Boulder Storm Water and Flood Management Utility

Regulatory floodplain mapping adopted by the Utility includes the federal FIS and FIRM and local floodplain studies adopted by the city.

Current floodplain studies adopted by the city for local floodplain regulation include the Boulder Creek & Major Tributaries – High Hazard Flood Zone, 0.5' Rise Floodway, adopted in 1989. This study is a compilation comprised of the FHADs for Boulder Creek, South Boulder Creek, and the Boulder and Adjacent County Drainageways, and adds the delineation of the locally adopted high hazard and conveyance zones. The underlying floodplain modeling used in the FHAD reports provided the base technical analysis to derive the high hazard and conveyance zones delineations within the federal floodplain boundaries.

Other significant local floodplain studies that have been adopted for regulatory purposes following the release of the FHADs were approved under the federal LOMR process, and include:

- Twomile Canyon Creek
- Boulder Creek, 6th Street to 17th Street
- Goose Creek, 28th Street to Foothills Parkway
- Bear Canyon Creek, upstream of Colorado Avenue

LOMRs and LOMAs have also been approved in the city of Boulder for individual properties and minor stream segments, and are too numerous to list here. Several more updated floodplain studies that will modify the FHAD reports are in process and will be completed in the next two years. These studies include Boulder Creek, from 55th Street to the western city limits, South Boulder Creek from the confluence with Boulder Creek to Eldorado Springs, Fourmile Canyon Creek, Wonderland Creek, and Gregory Canyon Creek.

The process for adopting new floodplain mapping studies is based on providing extensive community outreach and education in order to obtain public review and comment in the early stages of the adoption process prior to submitting new mapping studies to FEMA. This approach is intended to address community issues and concerns and provide the opportunity for citizens to fully understand floodplain changes before they officially occur on a regulatory map. Steps in the city's floodplain mapping adoption process are:

Floodplain Mapping Studies: Mapping studies may be initiated by federal, state, or local governments to remain current and accurate in managing and regulating the floodplain, and to recognize the benefits of public improvements that have been completed to mitigate flood hazards. The city generally revises major floodplain mapping studies following the completion of flood mitigation projects for substantial reaches of the city's major drainages. New floodplain mapping studies include a clear depiction of all floodplain zones, including the high hazard, conveyance, 100-year and 500-year floodplains. A detailed impact analysis of the changes created by the updated floodplain mapping, including a comparative evaluation of the existing floodplain with the new floodplain boundaries, is prepared. The analysis identifies land areas and existing structures to be removed from or added to the regulatory floodplain zones.

Direct Mailing Notification: Notification letters are mailed directly to those properties and property owners affected by the floodplain. The notice outlines the revisions proposed to ensure public awareness of any changes and invites the public to review the studies and attend public meetings.

Public Meetings: Public meetings are held to educate the community about the proposed changes and solicit public review and comment.

Compilation and Review of Public Input: City staff compiles and reviews public feedback to identify critical needs of the study to address and satisfy community concerns and determine if additional study revisions and repeated public meeting are required to further refine the new floodplain mapping.

Water Resources Advisory Board (WRAB): City staff presents the mapping study, impact analysis and citizen input to the WRAB, which recommends to the City Council whether to submit the study to FEMA for adoption. The WRAB also provides guidance concerning the impacts of the new mapping study on the CDUMP and capital improvement priorities.

Planning Board: A similar presentation adding WRAB recommendations is made to the Planning Board. The Planning Board reviews the information to address floodplain zoning impacts and regulatory needs and makes a recommendation to City Council concerning study submittal to FEMA.

City Council: City staff presents the mapping study with public comment and WRAB and Planning Board recommendations to City Council. City Council determines whether to submit the new mapping study to FEMA for adoption, and whether to pass an ordinance enacting interim restrictions for newly identified high hazard zones.

FEMA Application: If approved by City Council, staff submits the new floodplain mapping to FEMA for adoption. As of June 5, 2001, the Urban Drainage and Flood Control District reviews the study. If found acceptable, a preliminary floodplain map is prepared, FEMA issues a local published public notice, and a 90-day appeal period is initiated. If no valid appeals are received, FEMA issues a letter of notice that the new floodplain mapping study is effective. FEMA action may also include publishing a new Flood Insurance Rate Map (FIRM) for the community.

Local Map Adoption: Following the issuance and receipt of notice by FEMA that the new floodplain mapping study is effective, city staff notifies City Council and requests the City Manager to adopt the study for local regulatory purposes.

2. Status

Boulder is impacted by fifteen major drainageways. The status of floodplain mapping along each major drainageway is presented below:

a. Boulder Creek

The Boulder Creek Corridor Project, that produced the LOMR for the reach from 6th Street to 17th Street, was a joint use project between the City of Boulder and Boulder Valley School District. The project removed 13 multi-family residential structures (containing 169 dwelling units) near Boulder High School from the high hazard zone, and increased the flood capacity near the creek as part of an overbank excavation that became a park and athletic field expansion. The project was successfully completed in August 1993. The hydraulic analysis was completed using the US Army Corps of Engineers, HEC-2 Water Surface Profile computer model, and involved a triple split-flow analysis. The floodplain mapping changes were accepted by FEMA in a LOMR, dated June 14, 1995. The hydraulics of this stream reach were again investigated and updated in the “Final Hydraulics Report for Broadway Bridge Replacement at Boulder Creek” prepared by Love and Associates, inc., dated August 31, 2001.

An updated floodplain study for Boulder Creek, from 17th Street to 55th Street, was initiated in 1994, and incorporates 1993 topographic mapping developed for the city by Merrick and Company. Love & Associates, Inc. completed a draft floodplain study that was submitted to FEMA. The review comments received indicated the need to provide additional analysis, and the City is currently addressing these issues and will begin an intensive review process in 2003.

b. South Boulder Creek

The South Boulder Creek FHAD was completed in 1986, and has not been updated. In 1996, the University of Colorado (CU) contracted with Love and Associates, Inc., to study South Boulder Creek floodplain impacts at the CU-South/Flatiron Property located south of U.S. 36 and Table Mesa Drive. Love determined that significant flood spills would be expected west of the creek and north of U.S. 36. These spills had not been identified in the FHAD and raised serious concerns about flooding into developed neighborhoods inside the eastern city limits. Additional analysis by Taggart Engineering Associates, Inc., supported the spill findings and identified what is now known as the “west valley overflow.”

The west valley overflow crosses U.S. 36 at the South Boulder Road interchange. Affected neighborhoods include Pawnee Meadows, Thunderbird Court, Keewaydin Meadows, Frasier Meadows Manor, Chateau Village, Country Club Park, Wagner Manor, Park East First, Arapahoe Ridge and Meadow Glen. In addition, the Meadows on the Parkway Commercial Center, Friends School and Burbank Middle School are in this area.

To fully understand the flooding impacts for South Boulder Creek, the city has initiated a Request for Proposals to study updated floodplain hydrology and hydraulic conditions for the creek. The floodplain study is to be completed in 2004, and will provide the basis for updating the regulatory floodplain and developing workable flood management and mitigation strategies.

c. Bear Canyon Creek

The Bear Canyon Creek floodplain upstream of Foothills Parkway and Colorado Avenue was recently revised by a LOMR, dated October 29, 2002. Love and Associates, Inc., prepared the floodplain study to incorporate significant drainageway improvements and the new Broadway underpass. The 100-year floodplain was decreased by approximately 49 acres. Overall, 68 structures were removed from the 100-year floodplain, 8 from the conveyance zone, and 77 structures were removed from the high hazard zone.

Additional improvements downstream of Foothills Parkway to the confluence with Boulder Creek will be completed in 2003 to upgrade the Harrison Avenue levee to FEMA standards and improve conveyance across the Boulder Community Foothills Hospital property. A new underpass and transitional drainageway improvements at Arapahoe Avenue are planned for construction in 2004-2005.

d. Skunk Creek

The Skunk Creek drainageway from the Wellman Canal to the confluence with Bear Canyon Creek was improved to convey the 100-year flood as part of the development of the CU Research Park in 1990 and the Wellman Creek Townhomes in 1998. The CU Research Park improvements were approved for a LOMR in 1990 and were included in the 1995 FIRM. The Wellman Creek Townhomes improvements were approved by a 1998 LOMR and have not been reflected on the FIRM.

Other improvements along Skunk Creek have been completed at the Brookside Apartments (Moorhead Avenue and 27th Way) in 1990, the Baseline Avenue underpass in the mid-1990's, and at the new Broadway underpass completed in 2001. Floodplain studies were prepared for these changes. However, the FIRM has not been updated to reflect revisions to the Skunk Creek floodplain. Additional improvements are to be completed between Broadway and Moorhead in 2003, and an updated floodplain study for Skunk Creek will be initiated following completion.

e. Bluebell Canyon Creek and King's Gulch

There have been no changes in the flood mapping for Bluebell Canyon Creek or King's Gulch since adoption of the 1987 FHAD, and there are no plans to re-study this area.

f. Gregory Canyon Creek

In 1995-1996, several improvement projects were completed along Gregory Canyon Creek. Box culverts at Willowbrook Road, Aurora Avenue and Pleasant Street were replaced to provide emergency access during the 100-year flood. Upon completion, Love and Associates, Inc.

prepared a draft study to update floodplain conditions in the area. Stormwater & Environmental Consultants was retained to evaluate the floodplain study, and recommended that more detailed topographic survey was needed to accurately reflect the steep gradient conditions along the creek. The final floodplain study has been postponed to obtain additional survey data.

g. Dry Creek

Dry Creek No. 2 drainageway passing through the Flatirons Industrial Park is a side channel conveyance corridor for South Boulder Creek, and will be updated in 2003-2004 as part of the South Boulder Creek floodplain hydrology and hydraulic study.

h. Sunshine Canyon Creek

There have been no changes in the floodplain mapping for Sunshine Canyon Creek since 1987 and there are no plans to re-study this creek.

i. Goose Creek

The Goose Creek drainageway has been improved from the confluence with Boulder Creek to Folsom Avenue. Floodplain mapping updates were approved by LOMRs for Goose Creek downstream of 28th Street to Foothills Parkway. Upon completion of the Phase IV Goose Creek improvements up to Folsom Avenue, a new floodplain study for this reach will be completed and submitted for a LOMR.

j. Elmer's Two-mile Canyon Creek

Elmer's Two-mile Canyon Creek has been undergoing improvements south of Iris Avenue, and a new underpass is planned for Iris Avenue in 2004. Upon completion of these improvements, an updated floodplain study will be prepared and submitted for a LOMR for the reach from Iris Avenue to the confluence with Goose Creek.

k. Two-mile Canyon Creek

Twomile Canyon Creek was restudied in 1990 by Love and Associates, Inc. The floodplain for the entire creek from Goose Creek to the upstream city limits was updated by an approved LOMR issued in 1992.

l. Wonderland Creek

Wonderland Creek has experienced many drainageway improvements over the last fifteen years to convey projected 100-year flooding. However, the regulatory floodplain mapping has not been updated from the 1987 FHAD. Recent analysis of Fourmile Canyon Creek determined that flood projections for Wonderland Creek do not fully account for flood spills from Fourmile.

Fourmile Canyon Creek is unique in that a portion of the existing channel is perched within an alluvial floodplain. From the mouth of the canyon to approximately 19th Street, the floodwaters

that exceed the main channel's capacity will overtop the south bank and flow in a southeasterly direction toward Wonderland Creek. Previous flood hazard delineations for Wonderland Creek had not accounted for the true magnitude of spill flows from Fourmile Canyon Creek.

An analysis of the impacts of Fourmile Canyon Creek spills entering Wonderland Creek has been prepared. As a result of Fourmile spills entering Wonderland Creek, the number of structures affected by 100-year flooding increases from eleven to 50 structures. The increase in potential annual flood damage was estimated (+/- 25%) to be about \$200,000, with a present worth damage estimate increase of over \$3 million. Additional floodplain study and mitigation planning will be performed for Wonderland Creek in 2003 in conjunction with the ongoing Fourmile Canyon Creek floodplain study and mitigation master planning.

m. Fourmile Canyon Creek

In the 1980s, the land adjacent to Fourmile Canyon Creek was predominately characterized by rural subdivisions and commercial development along North Broadway with very low density lands. Minor drainage improvements were identified in the current floodplain master plan, and it proposed little emphasis on containment of the high hazard zone or 100-year floodplain. Since 1989, significant land area along Fourmile Canyon Creek has been annexed by the city and significant development has occurred and continues.

To address the changes, a re-analysis of the Fourmile Canyon Creek floodplain mapping was initiated in 1997. The re-analysis was additionally emphasized given the discovery of errors, inaccuracies and omissions in adopted 1987 FHAD that did not reveal flood spills from the lower south bank of the creek. The re-analysis, performed by Love and Associates, Inc., indicated significant discrepancies between the FHAD study and projected an expanded floodplain affecting more than 100 additional structures and numerous properties.

In June 1999 staff presented an agenda item to City Council requesting authorization to pursue a course of action to plan public improvements and pursue property and right-of-way acquisition in North Boulder along the Fourmile Canyon Creek corridor. As a result, City Council passed a motion acknowledging staff concerns regarding the Fourmile Canyon Creek corridor and authorized staff to continue analysis of possible mitigation options combined with a relevant and timely public process as part of a major drainageway planning effort. In addition, floodplain impacts to the Wonderland Creek drainageway needed to be analyzed concurrently because of floodwater spillage from Fourmile Canyon Creek. This has been assessed as part of a Wonderland Creek floodplain analysis and delineation study.

Love & Associates completed a damage analysis for Fourmile Canyon Creek as a part of the major drainageway planning effort. All property, structures and infrastructure within the Fourmile Canyon Creek 500-year floodplain were inventoried. Damage costs were estimated in accordance with Urban Drainage and Flood Control District methods. Average annual flood damages associated with the existing floodplain conditions for Fourmile Canyon Creek were estimated to be just over \$1 million, with an associated present value of approximately \$26 million. More than one third of the average annual damage for the entire project is associated with Reach 4 (located between 19th and 26th Streets), which is mostly located in Boulder County.

Most damages would result from flooding of the homes throughout this stream reach. Approximately one third of the average annual damages are associated with flooding of houses in the flow path of the water that spills from Fourmile Canyon Creek to Wonderland Creek.

Flood mitigation alternatives evaluated in the Fourmile Canyon Creek Major Drainageway Planning Phase A Report would reduce annual flood damages for Fourmile Canyon Creek by \$22.7 to \$25 million. In addition, there are considerable intangible benefits which would accrue from flood mitigation.

Following completion and acceptance of the Phase A study of Fourmile Canyon Creek and a review of this document by the Independent Review Panel, a “selected plan” was approved by City Council. This selected plan included the following tasks for implementation:

- Prioritize CDUMP acquisitions per the Phase A report and purchase damaged properties following a flood event;
- Recommend in the final plan that the city and Boulder County reexamine and enhance as necessary their emergency preparedness and response programs, including flood forecasting, early warning and disaster coordination and assistance. Review these regulations and programs in light of recommendations provided by the Independent Review Panel in their 9/28/00 review report;
- Floodproofing as an incentive for structures as a part of the CDUMP;
- Take into consideration larger flood events (than the 100-year flood) which can and will occur;
- Recommend the city consider a higher level of protection for critical buildings and infrastructure (schools, medical facilities, electric utilities, etc.);
- Recommend the city consider supplementing the early warning system as part of its update to the CDUMP, recognizing when the rise in stage is detected on the upper reaches of this creek, it may be too late to evacuate residents, and;
- Recommend the city consider additional monitoring and programs aimed at wildland fire mitigation and prevention and other potential changes in the upstream watershed.

An updated floodplain study for Fourmile Canyon Creek will be initiated in the near future for submittal to FEMA for a LOMR in order to manage the expanded floodplain.

n. Viele Channel

Viele Channel was improved over its entire reach in the mid-1970’s to convey the 100-year flood. There have been no changes to the flood hazard area delineation for Viele Channel since 1987 and there are no plans to re-study this channel.

2. Current Issues

Be Prepared for Floods

Implement a program to update hydrology and hydraulic floodplain studies, perform multiple-frequency storm analysis and detailed risk assessments, enhance early warning systems and multiple emergency notification measures, develop understandable response plans and workable recovery plans, and expand ongoing storm monitoring. Recommended implementation tools include developing state of the art hydrology and hydraulic models, designing detailed risk assessment processes, increasing coordination with the Emergency Management Office, enhancing the early warning system, installing multiple emergency notification measures, and enhancing the flood response and flood recovery plans.

Develop “State of the Art” Hydrology and Hydraulic Models: Use modern and advanced models to study updated hydrology and hydraulic flood conditions. Develop a citywide floodplain model combining the 13 separate floodplain models for each creek to permit analysis of multiple-frequency and multiple-storm event scenarios that may occur over more than one drainage basin at a time (we can not do this with existing models). This would allow staff to study the reaction of local floodplains based on varying storm conditions and how the storm drainage system responds to the impacts.

Action Item: Evaluate the costs and resources required for updating the floodplain studies for all major drainageways using modern and advanced study models, and identify program options for funding ongoing study activities and updates on an annual or periodic basis. Include in this evaluation the accuracy of base mapping, two dimensional modeling, and limitations of existing hydrologic study information. Define the scope, schedule and budget for this work. Prioritize this work with other Stormwater and Flood Management Utility work programs.

Perform a Detailed Risk Assessment: Using existing and/or updated flood information, prepare a detailed analysis of risk to structures and people. Estimates of financial losses and risk to life may be quantified and the greatest risks may be identified for flood preparedness and mitigation measures.

Action Item: Evaluate the costs and resources needed to prepare and assemble detailed risk assessments for all floodplain areas to be used in determining the greatest hazard reducing and cost-effective flood preparedness and mitigation measures. The risk assessments should consider both property damage and life safety issues. Define the scope, schedule and budget for this work. Prioritize this work with other Stormwater and Flood Management Utility work programs.

B. Floodplain Regulations

The City has had floodplain policies in place for over 30 years. During this time the city has been effective in mapping 100-year floodplains to identify flood hazard areas, developing master plans to pursue mitigation of flood impacts.

Local floodplain policies must also recognize multiple community objectives and balance overall community goals with the protection of Boulder citizens. Community goals that include maintaining affordable housing stock, fostering alternate modes of travel and maintaining quality

of life may affect floodplain policies and the manner in which they are implemented. These policies must address the flood hazard considering flexible alternatives that maintain the livability of the city. This requires an adjustment of policies from time to time to better protect and serve the citizens through multiple and creative approaches.

In addition the many critical environmental factors predominant in floodplain lands suggest that the approach to floodplain management should be oriented towards preservation of floodplains and their beneficial environmental functions and less toward structural measures. There is evidence that our local floodplain policy perspective is moving towards nonstructural flood mitigation measures as much as possible. A nonstructural policy has been applied to Boulder Creek since 1974, and the Boulder Valley Comprehensive Plan (BVCP) emphasizes this approach. Recent citizen response has also endorsed a more nonstructural approach to maintain the environmental, open space, recreational and aesthetic benefits that are derived.

Title 9, Chapter 9 of the Boulder Revised Code provides for regulation of floodplains. It establishes three specific flood zones used to manage and regulate development and uses within the floodplain. For more information about the floodplain regulations go to:

<http://www.ci.boulder.co.us/cao/brc/9-9.html>

1. Status

The floodplain is considered to include all land areas subject to inundation by floodwaters. The adopted regulatory floodplain is based on a predicted flood which as a one-percent chance of being equaled or exceeded in any given year. This area is commonly called the 100-year floodplain. Development within the floodplain must include flood protection measures which mitigate the risk of property loss or damage resulting from a 100-year flood. Within the floodplain, the following zones are defined:

- \$** Conveyance Zone - all areas in the floodplain which would be required for the passage or conveyance of the entire flood flow (measured in cubic feet per second) resulting from the encroachment (or blocking out) of the floodplain from the edges, allowing no greater than a maximum six-inch increase in the depth of flood waters. (The conveyance zone is usually a narrowed corridor within the floodplain.) This conveyance zone definition is more restrictive than that used by FEMA, which allows a maximum one-foot increase in floodwater depth. Development within the conveyance zone is subject to the restrictions applied to floodplain development and is further restricted to preclude development if the establishment of any use, or placement of any structure or obstruction, will create any rise in floodwater elevation.
- \$** High Hazard Zone - all areas in the floodplain where the product number of the floodwater velocity (in feet per second) multiplied by the floodwater depth (measured in feet) would equal or exceed four, or where floodwater depth would equal or exceed four feet. Development within the high hazard zone is most restricted, based on life safety considerations. In addition to the restrictions placed on the floodplain and conveyance zone (if appropriate), no new structures or additions to existing structures intended for human occupancy are permitted in the high hazard zone. No new parking lots and no

change in use of an existing structure from a non-residential to a residential use are permitted.

\$ Flood Fringe – those portions of the floodplain that are not in the conveyance zone or in the high hazard zone.

The city has regulations that pertain to the entire floodplain, as well as separate regulations governing land use within the conveyance zone and the high hazard zone. Regulations, which apply to the entire floodplain, include:

- A floodplain development permit must be acquired prior to any development within the floodplain;
- Flood proofing of buildings or structures must meet city standards;
- No hazardous materials may be stored at or below flood protection elevation, with the exception of underground fuel storage tanks which are constructed to prevent discharge into floodwaters and which are adequately anchored against a flood.
- Parking areas may not be located in areas where flood depths exceed 18 inches.
- Public facilities, such as hotels and other lodgings, schools, etc. must provide and maintain a flood warning system approved by the city manager.
- Rental properties in the floodplain must be posted with appropriate informational signs to warn tenants of flood hazards.
- Manufactured housing must be elevated on a permanent foundation so that the lowest floor is above the flood protection elevation, and the structure must be sufficiently anchored.
- New structures should be oriented with longitudinal axis parallel to the predicted direction of flow of floodwaters.
- Existing structures will be rehabilitated to conform with regulations when substantially expanded, enlarged, modified or improved.
- New residential structures must be elevated so that the lowest floor is at or above the flood protection elevation.
- New non-residential structures must be flood-proofed or have the lowest finished floor elevated above the flood protection elevation.
- Any new structure must be adequately anchored, constructed of material resistant to flood damage, and designed and located so that electrical, heating and ventilation, plumbing and air conditioning systems are not inundated.
- Fully enclosed areas that are subject to flooding must also allow for automatic equalization of flood forces by providing for entry and exit of floodwaters.

In addition to the regulations governing the floodplain, within the conveyance zone, uses, structures or developments which result in any rise in the elevation of the 100-year flood are prohibited. Within the high hazard zone, construction of new, or expansion, enlargement, modification or improvement of existing structures intended for human occupancy is not allowed.

Floodplain Development Permits

The city requires that a floodplain development permit be acquired for any development within the floodplain. The City Manager, through the Public Works Department is responsible for review and approval or denial of floodplain development permits and the development of conditions of approval where appropriate. Developments which propose a change in a watercourse must be referred to the Planning Board for recommendation. Permit approvals for development in the conveyance or high hazard zone do not become effective for twenty-one days following issuance and are subject to City Council review, public noticing, and appeal procedures.

The City assesses fees for the processing of floodplain development permits, variances and flood map revisions. The City also coordinates its floodplain regulations with several other agencies, each of which regulate to the 100-year floodplain standard. These agencies include FEMA, the Colorado Water Conservation Board (CWCB), the UDFCD and Boulder County.

Floodplain development permit applications are reviewed by City staff within the Public Works Department, who provide public notice of the application (if high hazard or conveyance zones are affected) and makes a recommendation of approval, with or without conditions, or denial of the application. Among the concerns considered in the review of a floodplain development permit are compliance with regulations governing floodplains, conveyance zones and high hazard areas, effects on drainage efficiency or capacity, whether the project will have an adverse environmental effect on the watercourse, including banks and streamside vegetation, effect of the project on adjacent, upstream and downstream properties, the relationship of the project to the Boulder Valley Comprehensive Plan and applicable floodplain management programs, and whether the cumulative effects of the project with other existing and anticipated uses will increase flood heights.

Floodplain development permit applications for the conveyance and high hazard zones are referred to the City Council as an information item. The City Council may call up the staff approval within 21 days of the approval. If called up, the City Council reviews the application, holds a public hearing, and reaches a decision concerning the development.

2. Current Issues

Preserve Floodplains

Implement a policy that recognizes a prescriptive floodplain easement that offers “beneficial functions” for flood hazard reduction, water quality enhancement, wetland protection, wildlife habitat, riparian corridors, recreation, alternate modes of travel, environmental relief, aesthetics, and urban open lands. Recommended implementation tools include public land acquisition, private land dedication and integration with multiple program activities.

Private Land Dedication: Development applicants are already required to dedicate lands impacted by major drainageways to provide a corridor for storm water conveyance under Chapter 10-5, B.R.C. 1981. This requirement could be expanded to include dedication and preservation of floodplain areas for both conveyance and flood storage, and where “beneficial functions” currently exist.

Action Item: Evaluate options with the Planning Department to encourage private floodplain dedications as part of development activities without restricting land use potential, and revising land use regulations to require dedication of floodplain areas serving beneficial functions in addition to the currently required dedication of conveyance zone areas. Consider other City objectives including community design, facilities and services, environment, economy, transportation, housing, social concerns and human services as articulated in the BVCP.

Prevent Adverse Impacts and Unwise Uses in the Floodplain

Update and develop appropriate regulation and land zoning, open land preservation and acquisition, multi-objective planning, acquisition and relocation of high hazard structures, and prohibiting unacceptable encroachments. Recommended implementation tools included adopting revised floodplain regulations (to avoid unacceptable floodplain impacts, create standards for critical facilities and improve life safety factors), consider guiding principals, expand property acquisition and urban open land preservation, and enhance storm water management activities.

Consider Recommended Floodplain Regulation Revisions that include:

- Maintaining the current high hazard zone standards prohibiting new structures intended for human occupancy.
- 500-year protection for critical facilities (consistent with development of the new Boulder Community Hospital and Foothills Housing development). Critical facilities would include among others publicly owned buildings, hospitals, managed care facilities and schools.
- Prohibiting adverse floodplain encroachments and impacts that would increase flood depths (consistent with the conveyance zone restrictions) or velocities, or reduce flood storage, to maintain the current carrying capacity of the floodplain, prevent creating high hazard conditions or increasing downstream flooding.
- Requiring safe emergency access routes to buildings during floods and ensuring that functional emergency exits during flooding are provided from flood proofed buildings.
- Requiring multiple storm level protection measures to account for flooding from storms greater than 100-year magnitude
- Lowering zoning densities in floodplains and offering possible transfer of development rights to avoid new floodplain encroachments
- Adopting a floodplain buffer to address mapping uncertainties and avoid future flood impacts.

Action Item: Prepare a detailed framework and benefits analysis of recommended floodplain regulation revisions to improve local floodplain management. Consider other City objectives including community design, facilities and services, environment, economy, transportation, housing, social concerns and human services as articulated in the BVCP.

C. Property Acquisition and Flood Mitigation

The Boulder and Adjacent County Drainageways Study (Greenhorne & O'Mara, Inc., 1984, 1987) was a joint master planning effort conducted by the UDFCD, Boulder County and the city. Phase A consisted of floodplain delineations for Bluebell Canyon Creek, Kings Gulch, Gregory Creek, Sunshine Canyon Creek, Fourmile Canyon Creek, Wonderland Creek, Elmer's Twomile Creek, Twomile Canyon Creek, Bear Canyon Creek and Skunk Creek, and the development and analysis of possible floodplain improvements for these drainages. Based upon estimated damages that would occur, alternatives were developed to mitigate or eliminate property damage and a cost-benefit analysis was performed using the damage reduction potential, construction and right-of-way costs, estimates of indirect and intangible benefits, and operation and maintenance costs associated with each alternative. Alternatives were evaluated based on design criteria, constructability and economy of installation, multiple use, and visual aesthetics. The Drainageway Plan recommendations underwent several public reviews and an additional review by a special Blue Ribbon Panel appointed by the City Council.

Phase B of this study included preliminary design of selected improvement alternatives, and development of cost estimates and an implementation plan for the 17 projects included in the Phase B report. Improvements to Goose Creek from Foothills Parkway to Folsom were identified as the top priority. The total estimated cost for all recommended improvements was \$21.7 million in 1987 dollars. The projects are eligible for funding from the UDFCD as master planned projects initiated by the local government.

The Master Plan for Boulder Creek Tributaries (1985) was developed by the Blue Ribbon Panel appointed by the City Council to develop recommendations for major drainageway planning in Boulder. The panel was directed to develop a plan which considers the individual characteristics of segments of Boulder Creek tributaries and which provides a high level of life safety protection; removes developed and undeveloped property from the 100-year floodplain using a minimum of concrete-lined channels; minimizes public cost and relates private cost directly to the benefit received, and; recommends not only a long-term plan of improvements but also a short-range program designed to eliminate the problems of high frequency, low-hazard flooding. The panel's plan was developed by re-examining the alternatives developed in the Greenhorne & O'Mara study and selecting and prioritizing alternatives using a set of evaluation criteria developed for the study.

1. Status

The *High Hazard Zone Property Acquisition Analysis* was completed in February, 1997 by Love & Associates. The analysis indicated there were a total of 279 structures located wholly or in part in the high hazard zone.

Because of the large number of structures in the high hazard zone, a rating system was developed based on potential threats to the safety of building occupants as well as the potential for damage to structures during the 100-year flood. Criteria included:

- Overall safety of individuals within flood water near the structure

- Ability of occupants to climb above flood water within the structure
- Structural stability during flooding
- Impact of rapid velocity flows
- Occupants trapped in below-grade living spaces
- Ability of occupants to leave or enter the building during a flood
- Use of the structure
- Site specific hydraulic conditions
- Other considerations

Of the 279 structures in the high hazard zone, 41 structures received the highest rating based on potential threat.

Since 1997, several projects and acquisitions have removed structures from the high hazard flood zone. Recent improvements along Bear Canyon Creek have removed all structures from the high hazard flood zone. Improvements along Goose Creek through the Mapleton Mobile Home Park will remove the majority of the structures that received the highest rating based on potential threat. Also along Goose Creek the City purchased and removed a single family residence. Along Boulder Creek the City purchased and removed the 18 unit apartment complex. Along Fourmile Canyon Creek the City purchased and removed a single family residence.

Total number of structures:

Major Drainageway	1997 Report	2002 Status
Boulder Creek	31	30
Fourmile Canyon Creek	14	13
Twomile Canyon Creek	8	8
Goose Creek	106	49
Elmer's Two-mile Creek	2	0
Gregory Canyon Creek	31	31
Skunk Creek	12	12
Bear Canyon Creek	73	0
South Boulder Creek	2	2
Wonderland Creek	0	0
Sunshine Canyon Creek	0	0
Bluebell Canyon Creek	0	0
Kings Gulch	0	0
Dry Creek	0	0
Total	279	145

Highest rated structures based on potential threat:

Major Drainageway	1997 Report	2002 Status
-------------------	-------------	-------------

Boulder Creek	5	5
Fourmile Canyon Creek	5	4
Twomile Canyon Creek	0	0
Goose Creek	22	3
Elmer's Two-mile Creek	2	0
Gregory Canyon Creek	7	7
Skunk Creek	0	0
Bear Canyon Creek	0	0
South Boulder Creek	0	0
Wonderland Creek	0	0
Sunshine Canyon Creek	0	0
Bluebell Canyon Creek	0	0
Kings Gulch	0	0
Dry Creek	0	0
Total	41	19

The current status of flood mitigation along each major drainageway is presented below:

a. Boulder Creek

Significant flood mitigation improvements to Boulder Creek were implemented as part of a joint use project with the Boulder Valley School District. Nine properties were purchased in the vicinity of Boulder High School and 13th Street. The structures were removed and the overbank area on the north side of the creek south of Arapahoe was excavated and graded to provide for additional flood conveyance and the construction of park and athletic fields. This work was completed in 1993.

Other properties along Boulder Creek that have been acquired and removed since 1989 include:

- City Tree House office structure on the South side of Boulder Creek east of the Library;
- Residence at 1234 18th Street, along the north side of Boulder Creek;
- 18-unit apartment complex at 299 Arapahoe just east of the Eben G. Fine Park site on the south side of Boulder Creek.

Other flood control improvements that have been made along Boulder Creek since 1989 include:

- Lower Arapahoe Avenue Bridge structure replaced just east of Broadway;
- 17th Street Bridge replaced with a 100-year structure;
- Conveyance/detention storage improvements along the creek through the University of Colorado's Research Park;
- Railroad underpass structure at Cottonwood Grove;
- Upper Arapahoe Bridge structure replaced above Eben Fine Park;
- 55th Street Bridge replaced with 100-year structure;

- Fixed concrete footbridge at Boulder High School replaced with a break-away structure, and;
- Final design and permitting is underway for replacement of the Broadway Bridge over Boulder Creek. Completion of this work is anticipated in late 2002.

Additional property acquisition is planned along Boulder Creek as identified in the High Hazard Zone Property Acquisition Analysis.

b. South Boulder Creek

In order to mitigate potential flooding to the adjacent Flatiron Industrial Park along the reach of South Boulder Creek north of Arapahoe Road, Love & Associates was retained by the city to develop different options for improvements to the creek from the BNSF railroad tracks to 700 feet downstream. Love & Associates prepared construction plans for the option selected. Work included removing trash, debris and selected trees from the channel bottom, downstream of the BNSF railroad tracks, removal of sediment immediately downstream of the railroad tracks, notching an existing drop structure and the removal of trash and debris from the spring runoff and additional trees further downstream. An agreement was established with the UDFCD to provide annual routine maintenance of this channel, starting in 1998, which will include trash and debris pickup, tree thinning and sediment removal.

The city of Boulder, Boulder County, the University of Colorado and the UDFCD funded a floodplain management and mitigation plan for South Boulder Creek to identify alternatives for floodplain management and mitigation that could be applied in the expanded floodplain and main creek corridor. Taggart Engineering Associates, Inc. prepared the South Boulder Creek Major Drainage Planning, Phase A (2001). The Phase A report was rejected by the Board of County Commissioners and the city Open Space Board of Trustees. The city conducted a series of public meetings and formed an Independent Review Panel and Citizen Advisory Group to review the report. Based upon this input, as well as recommendations for the Open Space Board of Trustees, Water Resources Advisory Board and Planning Board, the city developed a series of “next steps” and activities to enhance the management and mitigation planning for South Boulder Creek, as follows:

- Risk Analysis: Defining the hazards and problems created by South Boulder Creek flooding, providing technical analysis and evaluation of the conditions associated with flooding events and assessing possible benefits of flooding given the level of hazard.
- Flood Preparedness: Protecting life safety and reducing potential flood damages by addressing proactive measures that may be implemented to avoid flood risks, such as flood proofing and maintenance activities, ensuring awareness of flood hazards through education and regulation, offering timely warning in emergencies and providing for recovery following flood losses.
- Flood Mitigation: Developing acceptable and workable measures that may be implemented to reduce flood hazards, adopting guidelines and

parameters to assure that community values and objectives are achieved, seeking multi-objective outcomes that balance environment and society, and comparing the costs of measures with respect to benefits derived.

- Study Process: Outlining a process to follow toward achieving acceptable and beneficial outcomes, ensuring public involvement in community based activities, developing a scope and work plan to produce results and accountable actions, establishing coordination and cooperation with affected parties, setting a time line and adopting a plan for implementation.

c. Bear Canyon Creek

Significant flood mitigation improvements to Bear Canyon Creek have been implemented since 1989. These include:

- Underpass and trail connections to CU Main campus, Apache Trail and Williams Village – 1991;
- Trail reconstruction from Wellman Canal to Mohawk Drive – 1992;
- Two underpasses, riparian habitat widening and restoration, wetland creation, landscaping and trail reconstruction from Mohawk Drive to Gilpin Avenue – 1993;
- Floodway improvements, two underpasses and trail connections between Martin Drive and Moorhead – 1994;
- Mohawk underpass and flood capacity improvements – 1995;
- Gilpin underpass and flood control improvements – 1997;
- Replacement of Broadway underpass, reconstruction of Anderson Ditch crossing and channel improvements – 1999, and;
- Martin Park channel improvements to contain 100-year flows and storm sewer improvements including water quality pond construction - 1999.

Anticipated future projects include:

- Table Mesa Drive box culvert and separated grade crossing;
- Foothills Parkway to Arapahoe drainageway and greenway improvements.

d. Skunk Creek

Projects completed in the Skunk Creek drainage since 1989 include:

- In conjunction with the development of the CU Research Park, the University of Colorado completed Skunk Creek stream channel reconstruction, flood control improvements, wetland and pond creation, water quality improvements and trail construction from Foothills Parkway to Colorado Avenue – 1991;
- Trail construction and wetlands creation from Colorado Avenue to Wellman Canal – 1992;

- Underpasses beneath Baseline, U.S. 36 and the U.S. 36 on-ramp at Baseline – 1995/1996;
- Developer constructed improvements from Colorado Avenue to Wellman Canal including channel improvements, drop structure and wetland creation – 1996;
- Broadway underpass – 2000.

Flood mitigation and property acquisition was considered in the CEAP for the segment of Skunk Creek between Broadway and U.S. 36 which was approved in 2001. However flood mitigation work or property acquisition was not selected for implementation at this time.

Flood mitigation and property acquisition work is planned for 2003 between 28th & 30th Streets. There is also the potential for additional flood mitigation work along this drainageway pending the results of a drainageway specific plan.

e. Bluebell Canyon Creek / King's Gulch

No flood mitigation improvements or property acquisition along Bluebell Canyon Creek / King's Gulch have been initiated or planned.

f. Gregory Canyon Creek

Several flood mitigation improvements to Gregory Canyon Creek have been implemented since 1989. These include:

- Construction of box culverts under Willowbrook Road – 1996
- Construction of rock drop structures in the creek bottom between University Avenue and Pleasant Street – 1995
- Replacement of an existing culvert crossing under Pleasant Street – 1995
- Reconstruction of a rock wall upstream of Pleasant Street – 1995
- Inlet improvements to the existing culvert under 7th Street – 1995
- Construction of rock drop structures between 7th Street and Pennsylvania Avenue -1995
- Replacement of an existing culvert under Aurora Avenue and construction of associated rock drop structures, rock walls, and erosion protection upstream and downstream of Aurora Avenue - 1995

Additional property acquisition is planned along Gregory Canyon Creek as identified in the High Hazard Zone Property Acquisition Analysis, Love & Associates, 1997. However, because of the high cost and limited land area associated with property in this area, acquisition is a lower priority compared with other drainageways. There is also the potential for additional flood mitigation work along this drainageway pending the results of a drainageway specific plan.

g. Dry Creek

Flood mitigation improvements to Dry Creek were implemented as part of the 55th Street roadway improvement project. These included:

- Separated crossing at the Wellman Canal;
- Drainageway improvements upstream of the Wellman Canal to approximately Euclid Avenue, and;
- The Burlington-Northern Railroad replaced a railroad bridge over the Dry Creek channel to meet 100-year flood carrying capacity- 1998.

No additional flood mitigation improvements or property acquisition along Dry Creek is planned.

h. Sunshine Canyon Creek

No flood mitigation improvements or property acquisition along Sunshine Canyon Creek have been initiated or planned.

i. Goose Creek

Phase II flood mitigation improvements for Goose Creek between Foothills Parkway and 30th Street were completed in 1995. These included:

- Property acquisition
- Separated crossing of the Boulder and Left Hand and North Boulder Farmer's ditches
- Foothills Parkway to 30th Street channel and greenway improvements
- Box Culvert and separated grade crossing at the Burlington and Santa Fe Railway
- Box Culvert and separated grade crossing at 30th Street

Phase III flood mitigation improvements for Goose Creek between just west of 30th Street and just downstream of the Boulder White Rocks Ditch were completed in 2002. This project included significant property acquisition and the following major components:

- Separated crossing of 28th Street
- 100-year channel and greenway improvements between just west of 30th Street to just downstream of the Boulder White Rocks Ditch

Previously, no drainageway existed between downstream of the Boulder White Rocks Ditch and 30th St. The project created a drainageway through this area that removed numerous properties from the 100-year floodplain. The project also added a critical non-auto connection between the Central Area subcommunity and East Boulder, providing access to a major employment center, the Boulder Creek trail system and what will eventually be the City's largest park.

Several properties were acquired to as part of the Phase III project. These included:

- For the area between just west of 30th Street to 28th Street the entire Fowler property was acquired under eminent domain proceedings, and a portion of the Crouch and City Electric properties were also acquired based on a negotiated agreement
- The Branding Iron Mobile Home Park was acquired under eminent domain proceedings and a 1992 settlement agreement stipulated that City complete the flood mitigation project on the

west half of the mobile home park by December 31, 2000. A subsequent agreement extended this date and the completion of the Phase III work fulfilled this requirement

- For the area west of 28th Street, the Tebo/Chaknova property was acquired along with portions of the Chey Thuy and Credit Union properties.

The Goose Creek Phase IV project involves the area located within the Mapleton Mobile Home Park west to Folsom Avenue. The Phase IV project will include the following components:

- 100-year channel and greenway improvements through the Mapleton Mobile Home Park
- Separated crossing of the Boulder and White Rocks Ditch

To facilitate this project, the City purchased the Mapleton Mobile Home Park in 1998. The Phase IV project should be completed in early 2003.

Other property acquisition along Goose Creek since 1989 includes:

- Single family residence at 1650 Alpine Street

There is the potential for additional flood mitigation work upstream of Folsom Street pending the results of a drainageway specific plan.

j. Elmer's Two-mile Creek

In 1994, the City identified the reach of Elmer's Two-mile Creek behind the Willowbrook Townhomes just south of Glenwood Avenue for channel improvements to increase channel capacity, reduce perpetual maintenance activities, create wetland areas, and alleviate a persistent mosquito problem due to stagnant water in the channel. The City solicited the assistance of the Urban Drainage and Flood Control District's Maintenance Program to complete this work in 1994. The work involved the cleaning and widening of the creek channel bottom, lining of one side of the channel with large boulders, installing river rock (cobbles) in the channel bottom, constructing a couple of rock drop structures, armoring banks around bends, and establishing some wetland areas just upstream of the improvements.

Greenway improvements between Iris and Glenwood are currently planned and are being done in conjunction with the Parks and Recreation Department and the Urban Drainage and Flood Control District (UDFCD). The Parks Department is constructing a new park site south of Iris Avenue. The UDFCD is providing funding as part of the Park's Department project to make water quality and habitat improvements by removing the concrete trickle channel and revegetating the channel with native plants. The Greenways Program is funding a path connection between Glenwood Drive and the south boundary of the park. Design and construction of the project will be completed in 2001.

Drainageway and greenway improvements are planned for Elmer's Two-mile Creek between the confluence with Goose Creek and Valmont Road. These improvements will include a separated crossing of the Boulder White Rocks Ditch. A CEAP for this project was completed in 1998 as part of the CEAP for Goose Creek.

Property acquisition and flood mitigation alternatives for Elmer's Two-mile Creek upstream of Valmont to Glenwood were developed by McLaughlin Water Engineers. These alternatives are currently being reviewed by City staff.

k. Two-mile Canyon Creek

No flood mitigation improvements or property acquisitions along Two-mile Canyon Creek have been initiated or planned.

l. Wonderland Creek

Projects completed on Wonderland Creek since 1989 include:

- Wonderland Creek box culvert with trail underpass at Broadway;
- Developer constructed drainageway improvements from 47th Street to Valmont.

A box culvert capable of passing the 100-year flood under Valmont Road was completed in 1992. More recently, a project between Valmont Road and the confluence with Goose Creek was completed in cooperation with the city's Parks and Recreation Department and the Urban Drainage and Flood Control District. The project involved the construction of the Wonderland Creek channel and path between Valmont Road and North Goose Creek. The construction of the channel allows Wonderland Creek to convey all 100-year flows from the developed basin upstream of Valmont Road.

Spill flow from Fourmile Canyon Creek into Wonderland Creek was considered and addressed in the Fourmile Canyon Creek Major Drainageway Planning Study undertaken by the city, Boulder County and the Urban Drainage and Flood Control District. The spill flow from Fourmile Canyon Creek into Wonderland Creek is a significant issue. Between Foothills Parkway and Broadway, the spill flow would inundate approximately 40 additional structures (mostly residential) along Wonderland Creek during a 100-year flood. Also, during a 100-year flood, water would spill from Wonderland Creek into the Goose Creek drainage further complicating the floodplain situation within the city. Preliminary estimates indicate that several million dollars of potential damages would be caused by the spill flow. It is also likely that the high hazard flood zone due to the spill flow from Fourmile Canyon Creek may encompass several structures along Wonderland Creek.

The selected alternative for Fourmile Canyon Creek includes as a principle objective the elimination of spill flows to Wonderland Creek for the 100-year flood event. This approach would preclude the need for significant flood mitigation work and property acquisition along Wonderland Creek. On this basis, flood mitigation alternatives for Wonderland Creek were developed by Boyle Engineering. These alternatives are currently being reviewed by City staff.

m. Fourmile Canyon Creek

Flood mitigation improvements along Fourmile Canyon Creek have included:

- Box culvert and separated grade crossing at Broadway - 1995
- Channel improvements and trail construction from Yellow Pine to Broadway - 1998
- Drainageway improvements associated with the Pleasant View Soccer Complex

Property acquisitions along Fourmile Canyon Creek since 1989 include:

- Single family residence at 1800 Violet
- Single family residence at 2446 Sumac Avenue

The Fourmile Canyon Creek and Related North Boulder Flood Hazards study was initiated in 1997 to address the significant increase in development along the creek since the completion of the 1989 CDUMP and to correct errors, inaccuracies and omissions in previously adopted floodplain studies. In June 1999, City Council authorized staff to continue analysis of possible mitigation options combined with a relevant and timely public process. In addition, floodplain impacts to the Wonderland Creek drainageway needed to be analyzed concurrently because of floodwater spillage from Fourmile Canyon Creek.

In Phase A of this project prepared by Love & Associates, Inc., the hydrology and hydraulics of the Fourmile Canyon Creek basin and drainageway were reviewed and confirmed, flood damage potential was assessed and various flood mitigation options were developed and presented for review and discussion. These options were formulated in cooperation with the Greenways Program and in consideration of multiple objectives including habitat protection, water quality enhancement, storm drainage and floodplain management, trails, recreation, cultural resources and the overall objectives of the North Boulder Subcommunity Plan.

The plan selected by the city, Boulder County and the Urban Drainage and Flood Control District includes:

- Elimination of spill flows to Wonderland Creek and containment of the high hazard flood zone;
- Containment of the 100-year flood along Fourmile Canyon Creek within a larger drainageway if a larger channel in some of the reaches is justified in relation to the relative flood risks;
- Continued implementation of floodplain management regulations;
- Evaluation and enhancement, as necessary of emergency preparedness and response programs, including flood forecasting, early warning and disaster coordination and assistance;
- Completion of studies of the effects of proposed mitigation measures within the city on the Fourmile Canyon Creek floodplain downstream of the city limits;

- Monitoring and management of changes to the contributing watershed upstream of the city to prevent an increase in flooding and sediment loads within the city, and;
- Consideration in preliminary design efforts a variety of floodplain management tools which will take into consideration the various functions of the creek including flood conveyance, riparian habitat, open space, aesthetics, recreation, urban development, water quality and transportation.

Phase B of this study developed preliminary designs for the selected alternatives and presents this in a series of drawings and information suitable for budgeting and project development purposes.

The city and UDFCD, working with Love & Associates, completed two reports concerning Fourmile Canyon Creek downstream of Highway 119 to its confluence with Boulder Creek. These two reports are available for public review: 1) Technical Memorandum Hydrology - Floodplain and Damage Analysis and 2) Technical Memorandum – Alternative Analysis. City staff has met with property owners on two occasions to discuss the possible mitigation alternatives.

Based on IRP review and comments, City staff, working with Love & Associates, is also evaluating an additional flood mitigation alternative. This alternative requires that the study area be expanded to include all areas impacted by the spill flows from Fourmile Canyon Creek into Wonderland Creek and Goose Creek, as well as the shallow flood spill areas between these drainageways. The alternative will consider the costs and benefits of floodproofing individual structures within these floodplain areas assuming no drainageway improvements along Fourmile Canyon Creek are constructed.

n. Viele Channel

No flood mitigation improvements or property acquisition along Viele Channel has been initiated or planned.

2. Current Issues

Seek to Accommodate Floods, Not Control Them

Assess and implement planned and monitored system maintenance, nonstructural flood proofing, opening non-containment corridors, overbank land shaping to train flood waters, and limited structural (channelization) measures at constrained locations. Recommended implementation tools include updating mitigation master plans, reevaluating priorities for mitigation efforts to focus on high hazard mitigation and citywide efforts, and carefully considering the need for structural improvements.

Develop Updated Mitigation Master Plans that emphasize nonstructural measures, increase opportunities to realize beneficial functions in floodplains and seek cost-effective solutions that minimize major construction efforts. Reevaluate Priorities for mitigation efforts by:

- Addressing bottlenecks (bridges, culverts and roads) at critical locations.
- Acquiring floodplain lands to avoid channel improvements and eliminate hazardous uses.
- Performing non-structural overbank grading to increase conveyance and flood storage. The 1992 Boulder Creek Project at Boulder High School involved acquisition and removal of 169 residential units in the high hazard zone and non-structural overbank grading north of Boulder Creek to create the current open recreational fields. The \$3 million project also removed the Goss-Grove neighborhood from the high hazard zone by increasing conveyance near the creek and opened up the community-valued Boulder Creek greenway corridor.
- Targeting limited flood protection improvements for specific locations and working on restricted drainageway reaches to eliminate high hazards zone conditions and satisfy multiple objectives.
- Researching alternative mitigation approaches and improvements that may be completed for mid-stream reaches that don't require extensive downstream drainageway construction first to avoid adverse impacts from upstream modifications.

Action Item: Evaluate the costs and resources required for updating drainageway specific property acquisition and flood mitigation plans. Consider these policy objectives and an increased focus on cost-effective non-structural efforts. Define criteria to be considered in selecting the most suitable flood mitigation alternative. Define the scope, schedule and budget for updating these plans. Prioritize this work with other Stormwater and Flood Management Utility work programs.

Carefully Consider the Need for Structural Improvements by adequately assessing the alternatives that may be applied to avoid and minimize structural improvements, such as flood proofing, acquisition and relocation, and obtaining or supplementing flood insurance. These alternatives may involve acquisition and removal of structures, possibly affecting and relocating residents. Relocation of residents is a sensitive matter and concern must always be considered for the emotional distress such activities may create. However in some cases, acquisition and relocation of high hazard structures may offer greater long-term benefits, such as the immediate elimination of hazards to people and improved cost efficiency over performing channel improvements.

Action Item: Implement planning guidelines to include analyses of non-structural alternatives as part of all floodplain mitigation planning and design activities.

Focus on High Hazard Mitigation by primarily pursuing improvements in citywide locations that will reduce high hazard areas to the greatest extent possible.

Action Item: Identify locations to consider floodplain mitigation where high hazard conditions exist and prioritize by locations subject to the greatest risk levels.

Implement Mitigation Efforts Citywide to ensure that the most high-risk floodplain occupants are given priority and avoid putting all efforts into one or two drainage systems that consume significant funds for long periods.

Action Item: As outlined above, identify locations to consider floodplain mitigation where high hazard conditions exist and prioritize by locations subject to the greatest risk levels.

Consider Guiding Principles to apply to floodplain mitigation planning that support multiple objectives, community goals and public involvement. Such guiding principles are emerging from the Greenways master plan, and the IRP and CAG efforts on the Fourmile Canyon Creek and South Boulder Creek master plan studies.

Action Item: Develop a compilation of guiding principles to consider for floodplain management based on the BVCP, IRP and CAG recommendations, the Greenways Program master plan and other community and environmental objectives.

Expand Property Acquisition and Urban Open Lands Preservation activities for the most hazardous floodplain areas and areas with beneficial floodplain functions. Such acquisition applications would be for non-structural floodplain management and would not involve land purchases for structural mitigation (such as excavating channels).

Action Item: Review the current floodplain acquisition program and funding allocation and assess opportunities to be more effective and proactive in preserving floodplain areas.

Enhance Stormwater Management Activities to ensure ongoing design and maintenance of drainage systems and flood areas by clarifying specific practices for designated locations to ensure that Open Space and open lands preserving floodplains are designed and maintained differently from improved drainage facilities.

Action Item: In connection with general stormwater drainage maintenance policy recommendations, assess existing maintenance program activities and priorities and adjust as necessary to address this policy objective.

Public Land Acquisition: Continue with the high hazard property acquisition and building removal program we currently implement and enhance this activity to pursue undeveloped floodplain lands or creek corridors that offer “beneficial functions” and other community goals.

Action Item: Review the current floodplain acquisition program and funding allocation and assess opportunities to be more effective and proactive in preserving floodplain areas.

D. Flood Warning and Response

The UDFCD, the city and Boulder County sponsored the first study of Early Flood Warning Planning, Boulder Creek in 1977 (Leonard Rice Consulting Water Engineers, Inc., July 1977). This study compared five alternative warning systems in terms of lead-time for the city and critical areas of the canyons, credibility and reliability, first cost, annual operation and maintenance costs, flexibility, adaptability to phased implementation, and non-flood warning benefits. The study concluded that a system combining the use of radar installations and a ground observation network in Boulder would be the best approach to flash flood warning for the entire UDFCD. For the Boulder area only, a network of volunteer observers and automatic equipment was recommended as the best flood detection system.

By 1979, the city, Boulder County and the University of Colorado had jointly developed a Boulder Creek Flood Warning Plan which included a disaster management plan called the Multi-Agency Resource System (MARS) to address a flash flood on Boulder Creek, as well as other types of disasters. MARS is comprised of a Board of Directors (elected and appointed heads of Boulder, Boulder County and the University of Colorado) wherein decision-making responsibilities are centralized; a Situation Information Center charged with collecting, evaluating and displaying hydrologic and hydraulic data and advising the Board of Directors concerning the flood situation, and; a Resources Allocation Center to track and assign emergency response resources in accordance with directions from the Board of Directors. The warning plan addresses detection and evaluation of the flood; dissemination of warnings, and; responses to warnings with the goal of reducing possible loss of life and where possible, encouraging emergency flood proofing by property owners.

1. Status

The current Boulder Creek Flood Warning Plan was prepared in 1992 and revised in April 2001. The primary purpose of the plan is to minimize the potential for loss-of-life. The plan provides procedures for detection and evaluation of the flood threat; dissemination of the flood warnings to the public, and; response of the public to the warnings.

The earliest recognition of a potential flood threat for the Boulder and South Boulder Creek drainage basins is a heavy precipitation forecast by a meteorologist. The private meteorological service retained by the UDFCD provides the meteorological support for the plan. This service supplements National Weather Service (NWS) activities by focusing its support for the its support for the six-county geographical area comprising the UDFCD and tailoring communications to the individual concerns of each local government within the area. Forecasts are coordinated with the NWS Boulder office and provided to the Boulder Sheriff's Communications for subsequent dissemination. The Communications Center relays forecasts by executing an Emergency Services Group page. Participating organizations respond according to respective internal Multiple Agency Coordinating System procedures.

Twenty-one automated rain gages and six stream gages with the Boulder Creek and South Boulder Creek basins transmit rainfall data and current stream water levels to five base stations. These and other data are used to predict flood potentials and update local officials concerning anticipated flood problems at specific locations. The City of Boulder and Boulder County respond in accordance with procedures outlined in the Boulder County/City of Boulder

Emergency Operations Plan. The internal procedures and operating guidelines are maintained, practiced and routinely updated by each participating agency. Media coverage of flood hazards and the annual practice of the warning plan, are sought to heighten public awareness of flood hazards.

Flood awareness and warning concerns have been addressed in the city's on-going management planning efforts for Fourmile and South Boulder Creeks. The IRP for South Boulder Creek recommended that a specific flood warning and evacuation plan, to include early warning based on storm forecasting and high water alerts from the upstream basin, be developed and implemented promptly for South Boulder Creek. Flood preparedness tasks, including enhancements to current notification and warning systems, have been identified as a component of the next South Boulder Creek planning activities. IRP recommendations for the Fourmile Canyon Creek Major Drainageway Planning included reexamination and enhancement as necessary of emergency preparedness and response programs, including flood forecasting, early warning and disaster coordination and assistance for Fourmile Canyon Creek, as a part of the Utility Master Plan Update.

The UDFCD commissioned an evaluation of local flood warning program effectiveness for Boulder County and the City of Boulder in September 2001 (Agreement No. 01-08.11). Dr. Eve Gruntfest of the University of Colorado is the principal investigator. The study evaluated how well the warning process is working and how the Boulder population-at-risk perceives the warning and public education measures. Recommendations of the study include:

- “Public Education – We recommend conducting new education campaigns marketed to specific audiences as outlined by our demographic findings and to parents of Boulder High School students. The Internet and e-mail may be one avenue to do this. Public education *cannot* reduce the flash flood threat, nor can it assure that everyone at risk receives and responds to a warning during flash floods. However, educating the public may allow people to understand their own risk and may empower them to act appropriately during hazardous events. The link between awareness and action is not clear, but we believe that public education campaigns are worthwhile.
- Using new technologies and education techniques – We recommend a study of how UDFCD and Boulder can capitalize on new technologies and education techniques currently being used by other flood control organizations. The technologies that might be considered include, but are not limited to, enhanced GIS capabilities including flood inundation mapping, small scale GIS maps for basin or gauge location, and unique public education such as billboards as used by Clark County FCD. We also strongly recommend a review of the current paging system as several MACS participants indicated the system could be better. We recognize that more technology does not necessarily translate into reduced losses. However, different tools may assist before, during, and after an event. We encourage UDFCD and Boulder City/County Office of Emergency Management to investigate these resources.

- Involving local businesses and schools in the warning system, including the annual drill – We recommend education of the local business and schools along Boulder Creek as these business owners/managers/administrators/teachers represent an educated and semi-permanent population that may be depended upon by employees and constituents during a flash flood event.”

For more information about “An Evaluation of the Boulder Creek Local Flood Warning System”, go to:

<http://www.udfcd.org/FWP/LFWSresearch.htm>

The City recently commissioned John Henz of HDR to study the adequacy of the existing flood detection network and provide enhancement recommendations. A copy of this study is presented in Exhibit B.

This study notes that almost 90 percent of the gauges and stations in the existing detection network are located in the foothills to the west of Boulder. Only six rain gauges are located in on the plains. This focus on a western source of flooding was given a rude awakening on July 28, 1997 when the City of Fort Collins, 45 miles to the north, experienced a 10-14 inch thunderstorm flash flood that killed 5 people in and along Spring Creek. Over 85 percent of the rainfall fell at elevations below 6,000 feet into a basin that had few, if any, flood detection devices. The event occurred in a city that had received awards for its planning and diligent efforts to reduce the flood threat to life and property. Please note that the rainfall associated with this event was well above the 100-year return frequency and probably could not have been planned for any better at the time. Since the flood, Fort Collins has developed an enhanced flood detection network, an operational flood plain inundation mapping capability and a flood warning response plan that ties all the loose ends of operations, communications and response into a coherent effort. The question should be asked: is the City of Boulder ready for a Fort Collins type flash flood?

2. Current Issues

Be Prepared for Floods

Improve Coordination with Emergency Management Office: A focused effort to coordinate flood emergency preparedness activities with the city/county Emergency Management Office (Larry Stern, Emergency Management Director) should be initiated to compliment and integrate floodplain management activities and implement updated plans and actions.

Action Item: Consult with the Emergency Management Office to outline options and alternatives that may improve coordination between the two programs.

Enhance the Early Warning System: The early warning system is currently most effective for mountain canyon generated flooding on Boulder Creek, Four Mile Canyon Creek and South Boulder Creek. The system should be expanded to provide additional rainfall gauges, stream

gauges and weather stations throughout the Boulder area to provide flood monitoring in all 13 basins. Also, new developments in radar forecasting and satellite imagery may be incorporated to provide more effective and immediate monitoring and forecasting. Early warning monitoring stations could also be provided at additional locations to allow system redundancy and greater personnel access to current information.

Action Item: Consult with the Emergency Management Office and evaluate the costs and alternatives for expanding flood monitoring gages and devices.

Install Multiple Emergency Notification Measures: There are many systems available for disseminating emergency warnings. Currently we rely heavily on sirens and have access to a “reverse 911” calling system. Other types of warning systems include telephone auto-dialers, cable override, radio, tone-activated alert radios, and Internet. The system needs to be effective in reaching people inside homes, businesses and automobiles, in addition to people who are outdoors. A survey is currently being conducted by the University of Colorado at Colorado Springs in connection with the Emergency Management Office and UDFCD to study how people perceive the flood threat and how they would respond to warnings. The outcome of this research may provide additional alternatives and options in improving warning notification and emergency planning.

Action Item: Consult with the Emergency Management Office to review alternative notification measures and evaluate the costs associated with multiple systems.

Update and Enhance the Flood Response Plan: The current flood response plan may be updated and enhanced to better educate citizens in how to respond to a flood emergency. An enhanced plan that provides clear and concise direction to public officials as well as citizens will be more effective in protecting lives and making appropriate decisions during a flood event.

Action Item: Assess the existing flood response plans and evaluate enhancements, costs and resources for updating and developing improved plans. Define the scope, schedule and budget for this work.

Update and Enhance the Flood Recovery Plan: The flood recovery plan should be updated to incorporate current procedures and practices to meet community needs following a flood. The plan must address necessary recovery elements such as identifying early actions and decisions that must be made, meeting victim’s immediate needs, performing building and infrastructure damage assessments, re-establishing critical community services, acquiring or preserving post-flood properties to avoid future losses, issuing building permits for allowed reconstruction, and restoring normal city operations.

Action Item: Evaluate the costs and resources required to update and enhance the flood recovery plan. Define the scope, schedule and budget for this work.

E. Flood Insurance and Public Education

In 1968, Congress created the national Flood Insurance Program (NFIP) in response to the rising cost of taxpayer funded disaster relief for flood victims and the increasing amount of damage caused by floods. The NFIP makes federally-backed flood insurance available in communities that agree to adopt and enforce floodplain management ordinances to reduce future flood damage. For more information about the NFIP go to:

<http://www.fema.gov/nfip/>

The NFIP, through partnerships with communities, the insurance industry and the lending industry, helps reduce flood damage by nearly \$800 million per year. Further, buildings constructed in compliance with NFIP building standards suffer 77 percent less damage annually than those not built in compliance with the standards. Every \$3 paid in flood insurance claims saves \$1 in disaster assistance payments.

The NFIP is self-supporting for the average historical loss year, which means that operating expenses and flood insurance claims are not paid for by the taxpayer, but through premiums collected for flood insurance policies. An overview of the NFIP Community Rating System (CRS) Activities dated May 2002 is presented as Exhibit B.

1. Status

In 1990, the Federal Insurance Administration (FIA) developed the Community Rating System (CRS) that encourages activities to reduce potential flood damages within various communities. The incentive for participation is a reduction in flood insurance premiums paid by individual property owners within the jurisdiction of the community. In order to obtain these reduced rates, each community is required to submit an application to the Federal Emergency Management Agency (FEMA) and receive a classification based on the amount of floodplain management activities the community implements. The City first submitted this application in 1991. A verification visit by FEMA was conducted in the summer of 1992 to insure that the City was implementing the activities claimed in the application. The City received a Class 9 rating in October 1992 which resulted in a 5% reduction in flood insurance premiums paid by all flood insurance policy holders in the City.

The City recently implemented a more comprehensive internet web site for flood related information. It includes an interactive floodplain map that allows citizens to search for a specific address to be shown on the GIS-based floodplain map over the Internet. The web site also provides links to other agencies with natural hazard expertise such as FEMA. To access this web site go to:

<http://www.ci.boulder.co.us/pwplan/floodweb/index.html>

2. Current Issues

Help People Protect Themselves from Flood Hazards

Improve and enhance public interaction and involvement, available floodplain information, community outreach and education, self-help measures, flood proofing options, affordable flood insurance, and emergency preparedness. Recommended implementation tools included making a commitment to the Community Rating System (CRS), creating a Floodplain Management Office with dedicated staffing, developing a comprehensive Internet web site, and considering a flood-proofing program.

Make a Commitment to the Community Rating System to reduce premiums for flood insurance and encourage policy purchases, expand community outreach and education activities and implement technical support services to citizens. The city is currently involved in the CRS but has not pursued the best possible rating. The CRS provides numerous benefits to the community beyond reductions in flood insurance premiums, such as: (a) enhanced local floodplain management, (b) benchmark assessments, (c) federal technical assistance, (d) incentive based program maintenance, and (e) qualification for federal assistance programs. Primary credit categories include public information activities, mapping and regulations, flood damage reduction activities and flood preparedness activities. Greater commitment to improving the local CRS rating is resource dependent and may require additional human resources support (such as added staffing and/or outside contractual/consulting services). While Boulder provides numerous activities that would earn CRS credit, we have not taken full advantage of this program because of resources needed to request or maintain a higher rating.

Action Item: Evaluate the costs and resources needed to provide further focus on the CRS program, assess CRS activities that may be most beneficial and cost-effective to implement. Prioritize this work with other Stormwater and Flood Management Utility work programs.

Establish a central information source location identifiable to the public, provide adequate resources to implement and maintain required CRS elements, maintain required records for floodplain development, manage and utilize flood models for risk assessment, and offer direct community services and assistance for providing floodplain information, education and self-help flood protection consultations. A floodplain management office could directly coordinate with and compliment the activities of the Emergency Management Office (EMO) by providing educational and planning services for floodplain preparedness in advance of flooding. Such an office could also be coordinated with Boulder County floodplain management efforts to recognize the interface between the two local governments.

Action Item: Evaluate the costs and resources needed to implement activities that better support community information and customer service programs without creating a new and separate program office group. Identified activities may be distributed to appropriate departments and work groups.

Enhance the existing internet web site for natural hazards. With the high level of Internet access and usage in Boulder this tool could provide direct public access to important floodplain information, such as floodplain maps, letters of map revision, flood insurance information and a record of elevation certificates for buildings.

Action Item: Evaluate existing information sources that may be cost-effectively converted to an Internet format and identify resource needs to create additional and enhanced web site information.

Manage and organize information related to stormwater and flood management work programs in a manner that supports retrieval, dissemination and evaluation. The City has

Action Item: Identify the types of information that should be managed and organized. Evaluate the costs and resources needed to expand existing electronic based information management systems to accommodate this information.

Create a Flood Proofing Program to help citizens protect their property through onsite staff consultation, the provision of self-help information and possible low-interest loan programs to construct flood proofing.

Action Item: Evaluate opportunities and possible costs and funding mechanisms to create a flood-proofing program that may assist property owners in protecting flood prone structures. Prioritize this work with other Stormwater and Flood Management Utility work programs.

F. Stormwater Drainage

The Stormwater Collection System Master Plan (WRC Engineering, Inc., 1984) was completed in three phases to supply the city with a master plan to guide CIP development. The first phase covered the hydrologic aspect of the stormwater collection system and included a review of existing hydrologic data, development of hydrologic computer modeling of the existing storm drainage system, and correlation of computer modeling with existing data. Phase II evaluated the hydraulic capacity of the existing storm drainage system, identified existing and potential collector system drainage problems within the study area, and identified a matrix of alternative improvements to alleviate the problems. Phase III consisted of the completion of preliminary design of the selected improvement alternatives.

The stormwater collection system improvement alternatives were evaluated in terms of cost, whether or not they provided a higher level of flood protection (i.e., 5-year.) For commercial and industrial areas and for lines which parallel or cross arterial streets, the ability to reduce or minimize street flow in areas where the existing storm drainage system was inadequate, and whether or not they provided stormwater release points for irrigation ditches within the city. Fifty-four storm sewer improvement projects, a waste way, one culvert and an area inlet were selected and preliminary designs for these projects were completed.

Irrigation ditches also have an important influence on stormwater collection and drainage within the City. These ditches were built many years ago and were constructed in such a way as to intercept historical drainage. Depending on the amount of rainfall, stormwater flows may exceed the capacity of the ditch and spill from the ditch in an uncontrolled manner.

The city of Boulder, Boulder County and the Urban Drainage and Flood Control District completed the Boulder Gunbarrel Area Outfall Systems Planning Study in 1987. This study analyzed flooding problems in the area defined by Highway 119, Dry Creek No. 2, Jay Road, Boulder Creek and Gunbarrel Hill/95th Street. Problems in this area were caused by uncontrolled overflow of stormwater from irrigation ditches which intercepted runoff and diverted it to adjacent basins causing overflows. Piecemeal development and the lack of comprehensive master drainage planning also contributed to the drainage problems. The selected alternative in this study included increasing the capacity of existing facilities, providing for controlled overflows of irrigation ditches, providing new drainage facilities in areas which had none, controlling erosion, and continuing a strong floodplain management program as the area continued to develop. Elements of the selected alternative were prioritized in terms of areas in which the hazards were perceived as most severe, including Gunbarrel Road through the Gunbarrel Estates Subdivision; Spine Road from 63rd Street to Dry Creek No. 2; and the Boulder Creek Supply Canal near Jay Road.

1. Status

Other miscellaneous hydrology and hydraulic reports concerning the city's stormwater collection system have been completed including the following:

- Draft Preliminary Hydraulic Report – Broadway Reconstruction, Moser & Associates, July 31, 2001
- Hydrology Update – Stormwater Collection System Master Plan for North Boulder, Love & Associates, June 8, 1992
- Mapleton Hill Drainage Master Plan, Love & Associates, March 30, 1993

Since the adoption of CDUMP the following stormwater collection system projects have been completed:

- DC-4: Pennsylvania Avenue
- DC-5: East Euclid Avenue and Sycamore Avenue
- BC-1: Lehigh Street at Bear Canyon Creek
- DC-2: Folsom Street From Colorado to Boulder Creek
- BC-3: Kohler Drive and Dartmouth Avenue to Broadway and Lashley Lane (partial)
- BC-5: Moorhead Drive from Martin Drive to Bear Creek (partial)
- WC-1: Broadway/Cherry Avenue and Silver Lake Ditch to Broadway and Wonderland Creek (partial)
- SC-1: Sunnyside Lane from Baseline to Skunk Creek (partial)
- FM-1: Colorado State Highway No. 7 to Fourmile Creek along Broadway (partial)
- WC-2: North Broadway from Poplar to Wonderland Creek (partial)
- GC-1: Foothill Parkway
- WC-5: Valmont Road from Sterling Drive to Wonderland Creek (partial)

In addition to these projects other stormwater collection system work that has been initiated includes:

- Mapleton Hill - This work involved the installation of a new, larger storm sewer line in 4th Street between Concord and Dewey, in Dewey between 4th and 6th Streets, and in 6th Street between Dewey and North Streets. This work was completed in 1995. This new system was tied into an existing storm sewer system that is undersized and not able to handle the 2-year storm event downstream. McLaughlin Water Engineers, who had designed the improvement on Dewey Street, began preparation of preliminary engineering design drawings for improvements to the downstream system. This design involves the upsizing of the existing system in North Street, between 6th and 13th Streets, and installation of a new system in North Street between 13th and 19th Streets. This work has been postponed due to other priorities.
- Martin Drive Storm Sewer - A new storm sewer line was installed in Ash Avenue between Martin Drive and Moorhead Avenue and also in Martin Drive from Moorhead Avenue to half way between Moorhead Avenue and Ash Avenue. The existing lines in the back yards were plugged and abandoned in place, and all storm flows were rerouted down the new storm line in Ash Avenue. This work was completed 1995.
- Upper Goose Creek - McLaughlin Water Engineers was hired to review and assess the current Phase >B' Major Drainageway Master Plan and the Stormwater Collection Master Plan for improvements to the drainage system in the Goose Creek drainage basin upstream of 19th Street. This work has been postponed due to other priorities.
- Holyoke Drive - Construction of a storm sewer and inlets along Holyoke Drive to intercept nuisance flows coming from Table Mesa was substantially completed in 1998. The new storm sewer was connected to an existing outfall pipe to Bear Canyon Creek near the intersection of Ithaca and Wildwood.

2. Current Issues

Maintain and preserve existing and natural drainage systems

The stormwater drainage master plan was last updated in 1984. It has provided a working basis for the Utilities Division for over 15 years. However, the assumptions used and priorities indicated should be periodically reviewed for consistency with current development patterns and design philosophies.

Action Item: Define the scope, schedule and budget for the stormwater drainage master plan update. Define criteria to be considered in selecting the most suitable drainage alternative. Identify preliminary work that should be accomplished in order to increase the efficiency of the master plan update analysis.

Implement a maintenance program that clearly defines efforts to maintain gutters and pans, storm inlets and catch basins, storm sewers, open drainage swales, culverts and bridges, irrigation ditch interfaces, sediment and debris traps and detention facilities.

Action Item: Assess existing maintenance program in light of this policy objective. Include this as a scope item in the stormwater drainage master plan update.

The long-term management and maintenance of detention facilities should be considered to assure the long-term effectiveness of detention facilities. Detention facilities are required for all new development consistent with regional urban drainage criteria. However, the City does not typically own, manage or maintain these facilities.

Action Item: The City is currently determining locations and pertinent information for all existing detention facilities. A GIS layer will be developed to capture this information and could be used to assess the current functionality of these facilities. The information could also be used to assess the cost of long-term inspection, management, maintenance and enhancement of these facilities. Specifically consider these issues for existing residential areas that have detention ponds that serve multiple properties or receive runoff from public rights-of-way. Decide if this or related issues deserve consideration as part of the scope of the stormwater drainage master plan update.

Acquire public rights-of-way and easements for all natural and existing drainage systems, such as creeks, swales, detention facilities and storm water improvements.

Action Item: The City has recently assessed the status of all easements. A GIS layer was developed to capture this information and can be used to assess the cost of acquiring additional easements to meet this policy objective. Decide if this or related issues deserve consideration as part of the scope of the stormwater drainage master plan update.

Protect the natural features and functions of the existing drainage systems and care for their health to improve the effectiveness of these systems.

Action Item: The Greenways Master Plan was recently completed for Boulder Creek and six major tributaries. This plan considered the natural features and function of these tributaries as well as other objectives related to drainage, transportation, recreation and culture. This approach can be used to assure this policy objective is met for other major drainageways.

Reduce and manage developed runoff

Update drainage regulations and design standards to improve detention pond facilities and features to better attenuate runoff, such as requiring lengthened flow paths, pervious separations between impervious surfaces, increased numbers of storage elements (widened swales, incidental ponding on roofs, landscaping and paved areas, and underground storage devices), multiple stage

detention ponds, regional detention ponds, and reduction in impervious ground cover (reduced building footprints, alternative surface paving, increased tree cover, and pervious landscaping).

Action Item: Assess design standards in light of this policy objective. For example, the City uses the 2-year storm for residential areas and the 5-year storm for commercial areas consistent with regional urban drainage criteria. The City should consider the selected design storm, balancing the benefits of drainage improvement with the impacts and costs of constructing the associated storm sewer system.

Require development activities addressing drainage to propose multi-objective drainage systems and corridors to provide for storm water quality, open space, recreational area, water conservation and other possible functions.

Action Item: Assess design standards in light of this policy objective. For example, site drainage designs could be required to convey runoff to landscaped areas prior to discharging to a collection system to reduce runoff volumes and landscape irrigation demands. Natural drainage paths could be reserved on developing lands to recognize natural conveyance corridors having natural erosion features and environmental benefits.

Require developed runoff system evaluation and design based on multiple storm frequencies to ensure that any newly planned system is optimized to be effective, adequate and functional for multiple storm events.

Action Item: Assess design standards in light of this policy objective. For example, the city currently requires detention based on maintaining the 10-year historic release, but requires storm sewers be designed based on the 2-year and 5-year events. 3-stage outlet structures (2/10/100) or detaining the volume required to release the 10-year storm at the 2/5-year rate should be considered.

Eliminate drainage problems and nuisances

Reduce or eliminate nuisance drainage to public rights-of-way from the discharge of groundwater and sump systems, and constant flow conditions that may create an icing or slipping hazard or street and sidewalk puddling.

Action Item: Consider standards and plans to address how to best eliminate these nuisance waters. For example, the City currently requires a minimum 18-inch diameter for storm sewers, but in areas where a pipe is only needed for groundwater a smaller size pipe might be more appropriate. Another problem is that the development engineer may indicate that groundwater discharge is not a problem. Under the City's current code, it isn't a problem until it's a problem so we don't have an efficient way to require improvements at the time of initial construction. Once a structure is built and occupied, it is a much bigger headache both technically and politically to get the situation resolved. Should we go as far as to require all structures with subsurface improvements to be adjacent to storm sewers? Is there a more reasonable way to

address this? Further define this issue and include a more detailed assessment as a scope item for the stormwater drainage master plan update.

Develop basin area plans to retrofit drainage systems where no systems have been provided and inadequate drainage is present. This should include runoff flows from public rights-of-way crossing private lands, runoff obstructions resulting from public improvements, improving public convenience, managing frequent flow conditions, and avoiding the transfer of drainage problems from one area to another. This should also include limiting the discharge of storm runoff quantity greater than the historical amount into irrigation ditches.

Action Item: The opportunity for regional detention facilities should be evaluated to identify potential locations for creating regional detention ponds and developing options for implementing improvements. Problem areas should be identified so that improvements by various property owners could be intelligently coordinated? Further define this issue and include a more detailed assessment as a scope item for the stormwater drainage master plan update.

Provide a clear point of contact for drainage questions and complaints, education for individual responsibilities with respect to drainage and runoff, and a proactive and responsive organizational framework for addressing community drainage problems and nuisances.

Action Item: Assess existing procedures in light of this policy objective.

G. Stormwater Quality

The Clean Water Act (CWA) of 1972 mandated the development of federal programs to protect waters throughout the United States. Up until recently, CWA focused on management of point source pollution, such as wastewater treatment discharges through a permit system. The Water Quality Control Division of the Colorado Department of Public Health and Environment (CDPHE) is the state agency charged with implementing CWA permitting requirements. Among these regulatory responsibilities are the implementation of stream use classifications and numeric standards established by the Water Quality Control Commission, issuance of discharge permits and enforcement. Standards and use classifications have been set by CDPHE for Boulder Creek and its tributaries. CDPHE also prepares the 303(d) list, which identifies water quality limited segments requiring Total Maximum Daily Loads (TMDL), as specified under the CWA. The lower segment of Boulder Creek is included on the 303(d) list and is currently undergoing a TMDL evaluation. Completion of this evaluation is targeted for December 2000. On July 11, 2000, the Environmental Protection Agency (EPA) promulgated the final Total Maximum Daily Load rule. The rule seeks to improve implementation of the TMDL program under the CWA. Under the revised TMDL program, clean-up plans will be developed within 10 years.

In the 1980's, the Environmental Protection Agency (EPA) began addressing other pollution sources referenced in the Clean Water Act, including non-point source discharges such as stormwater runoff from urban areas. During the time the Clean Water Act was being amended to address stormwater quality, the City developed the 1989 CDUMP which included a Stormwater Quality Program to address water quality issues related to stormwater runoff. Since

then, the City's Stormwater Quality program has been involved in a number of activities, including the following:

- Stormwater Education Program: this award-winning program includes both school based (WatershED curriculum, Children's Water Festival) and community based programs (storm drain stenciling, informational brochures).
- Illicit Connection and Illegal Dumping Program: includes assistance in spill response and enforcement activities.
- Boulder Creek Water Quality Monitoring : includes monthly baseline chemical, and bi-annual biological (stream insect) monitoring
- Storm Sewer Outfall Inventory: includes mapping and water quality screening of all storm sewer system outfalls discharging to Boulder Creek and its twelve tributaries and thirteen ditches.

The intent of these programs is to reduce pollutant loading from the city's storm sewer system and support community water quality values as stated in the Boulder Valley Comprehensive Plan (BVCP), CDUMP, Greenways Master Plan and other master plans which address Boulder Creek and its tributaries.

1. Status

a. Phase II Stormwater Quality Regulations

In the past, federal regulations focused on controlling and permitting discharges from point sources such as wastewater treatment plants and industrial discharges. In recent years, the EPA has expanded its discharge permit system to include discharges from storm sewer systems. This expansion of the permit system is directed by the CWA Stormwater Quality regulations promulgated in 1990 and takes a two-tiered approach. Phase I of these regulations required urbanized areas with populations greater than 100,000 to permit their storm sewer systems. Regulations for Phase II were finalized in October 1999 and require urbanized areas with populations greater than 50,000 to permit their storm sewer discharge systems. The Colorado Department of Public Health and Environment will administer stormwater quality permits, under the Colorado Discharge Permit System. Regionally, the cities of Boulder, Longmont, Louisville, and Laffayette and the towns of Erie and Superior, as well as Boulder County are subject to the Phase II regulations which take affect March, 2003.

Traditionally, discharge permit compliance has been based on water quality monitoring of pollutant discharges to confirm that a discharge is meeting numeric limits. Rather than numeric limits, compliance with the Phase II stormwater quality regulations focuses on the implementation of stormwater management programs which provide water quality protection. Phase II Regulations call for the impenetation of six such programs, or "Minimum Control Measures". These include the following:

- MCM #1: Public Education and Outreach: Implement a public education program to provide information on stormwater impacts.

- MCM #2” Public Involvement and Participation: Provide opportunities for the public to participate in program development and implementation.
- MCM #3 Illicit Discharge Detection and Elimination: Prohibit illicit discharges to the storm sewer system.
- MCM #4: Construction Site Stormwater Runoff Control: Implement a program to reduce pollution from construction site runoff for sites larger than 1 acre in size.
- MCM #5: Post-Construction Stormwater Management For New Development and Redevelopment: Implement a program to reduce runoff pollution from new development and redevelopment.
- MCM #6: Pollution Prevention and Good Housekeeping for Municipal Operations: Implement operation/maintenance/training programs to prevent or reduce runoff pollution from municipal operations.

b. Boulder Creek Watershed Study

The City recognizes the importance of watershed protection as expressed in numerous resolutions passed by the City Council and advisory boards and by its adoption of watershed and water quality protection provisions in the Boulder Valley Comprehensive Plan. Thus, in 1997, the Boulder Creek Watershed Study was initiated to provide support for a comprehensive, watershed approach to compliance with the regulations and the protection of Boulder Creek water quality. The study involved the development of a water quality assessment tool, which can be applied to large or small sub-basins within the watershed. The assessment tool combines water quality, riparian habitat and land-use data with appropriate resource goals to characterize each sub-basin and help support management decisions for these basins. The study was a multi-year project which used a stakeholder involvement process to incorporate input and concerns from the community. A technical advisory group was used to identified key issues of concern or significant resource opportunities within the watershed .

One of the most important elements of the Study was the development of a Boulder Creek Watershed GIS coverage. The Watershed GIS and related applications include stream condition and source water protection applications. A Watershed Management Model (WMM) was created and applied to urbanized subbasins of Boulder Creek in the city. The WMM estimated annual non-point source stormwater loads from direct runoff based on surface water quality data from the Denver area and predicted runoff volumes. The model estimated annual runoff pollution loads for nutrients, heavy metals, oxygen demand and sediment for subbasins delineated by McLaughlin Water Engineers. A statistical method of analysis was used to sort the predicted loadings into categories ranging from very high to low loadings. A similar analysis was conducted for natural resources such as aquatic habitat quality, wetland acreage and ranking of good to poor quality were developed.

The Watershed Study and GIS and associated rankings can be used to direct Best Management Practice (BMP) implementation and guide prioritization of water quality and habitat improvement projects for subbasins within the city.

c. Aquatic Habitat Survey

During the summer of 1995, the City of Boulder Stormwater Quality Program surveyed 46 linear miles of stream in the Boulder urban area using the EPA's Rapid Bioassessment Protocol (RBP). RBP is an inexpensive screening tool used to determine if a stream is supporting or not supporting a designated aquatic life use. The data collected in 1995 provides a characterization of aquatic habitat based on three categories, depending on the relative importance to aquatic life. The three include the following:

- Primary parameters: stream bed characteristics
- Secondary parameters: channel morphology
- Tertiary parameters: bank stability

The RBP data collected during this survey were incorporated into the Boulder Creek Watershed GIS. The data provides an indication of the health of the aquatic ecosystem and ratings can be used to assess the relative impacts of water quality and urban hydrology. The percent of good, fair and poor habitat as indicated by the RBP data is summarized for each tributary in the attached basin summary tables for Boulder Creek and its tributaries.

During the development of the Greenways master plan, results of this aquatic habitat assessment was used to set priorities for environmental projects identified for this master plan. The priority of water quality objectives developed for the Greenways Master Plan reflected the RBP ranking of reaches of the tributaries within the urban area. In addition, it is expected that this information will help in the development of implementation strategies for this CDUMP update.

d. Boulder Creek Subwatershed Classification System

Using information from the Boulder Creek Watershed Study and the Aquatic Habitat Survey, the Boulder Creek Sub-watershed Classification System was developed. The purpose of the classification system is to:

- Guide decisions within the Boulder Creek watershed
- Provide direction for land management strategies
- Prioritize public projects and master planning strategies to address impervious cover and reduce pollutant loadings
- Integrate water quality protection into flood management project design

The classification system is based on the following:

- Extent of imperviousness
- Projected pollutant loading due to land uses in each basin
- Health of the stream corridor as indicated by national resource conditions
- Desired conditions based a combination of impervious cover and stream corridor priorities developed in Greenways Master Plan update

e. Stormwater Regulatory Compliance and Watershed Management

A watershed approach to compliance with the Phase II Stormwater regulations offers the

opportunity to leverage existing local resources to create a more comprehensive and effective process for water quality protection. In accordance with BVCP policies, which support regional water resource planning, the city began discussions with Boulder County, to identify appropriate areas of coordination. A City-County task force began meeting in 1998 to explore the practicalities of a joint stormwater program. These discussions led to a successful County proposal to the EPA for 104(b)(3) grant funding for County jurisdictions to explore coordination of compliance with the federal Phase II Stormwater Regulations.

Since February 1999, the County and the Cities of Boulder, Longmont, Louisville, Superior, and Erie have participated in a series of monthly meetings to discuss a coordinated, watershed approach to compliance. The group calls itself Watershed Approach to Stream Health (WASH). In 2003, the WASH partners entered into a five year, Intergovernmental Agreement (IGA) and submitted joint application to be covered under the State's General Phase II Stormwater Discharge Permit. The IGA and WASH Plan outline the implementation of programs required to comply with Phase II regulations and to meet community water quality standards.

2. Current Issues

Comply with Water Quality Regulations

Implement a stormwater management program that meets the requirement of Phase II Stormwater Regulations. These requirements can be met in part through participation in the Watershed Approach to Stream Health (WASH) regional stormwater management program as outlined in the WASH Plan.

Action Item: Determine resource needs for WASH program implementation. Ensure adequate funding and staffing of each of the six minimum control measure.

To implement a number of the minimum control measures (MCM) required under Phase II Stormwater Regulations the city must have adequate legal authority. This authority is primarily focused on the city's codes and ordinances. In addition, specific MCMs require ordinance language to implement programs and provide basis for enforcement.

Action Item: Evaluate adequacy of legal authority to implement Phase II MCMs and identify appropriate code and ordinance changes required.

Reduce the Amount of Runoff

Implement an integrated sub-basin master planning process to provide overall direction for basin and corridor developments and CIP program. Process should integrate flood, drainage and water quality benefits and the costs associated with capital construction, land acquisition and ongoing maintenance/operation.

Action Item: Develop criteria for ranking criteria to prioritize various objectives within each sub-basin. Criteria may include flood management priority (e.g. high hazard areas), water quality pollutant loading, cost-effectiveness, environmental impacts and

ability to coordinate with other city projects. Develop a sub-basin classification system for water quality, flood management and drainage using GIS. Evaluate cost and resource needs to develop GIS capabilities to support this level of sub-basin master planning efforts.

Provide adequate groundwater recharge and reduce runoff in basins by addressing impervious cover. Strategies to reduce impervious surfaces include undeveloped lands through land acquisition, and Non-Structural BMPs, porous paving, landscape standards, preservation of rural zoning designations

Action Item: Develop information needed to assess cost of implementing the various elements of an impervious surface reduction program. This may include the development of a public lands inventory and GIS, and assessing the impact of requiring BMP to reduce impervious areas.

Improve Quality of Runoff

Implement design and development standards, construction erosion and sediment control, which require BMPs to minimize the impact of runoff on water quality. In addition, incorporate water quality protection in flood control design, construction and maintenance projects.

Action Item: Evaluate the use of design standards such as “Better Site Design” and other protection strategies to address construction and post construction development impacts. Evaluate the impact to the development community of various BMP and runoff reduction strategies. This may include the requirement that post and/or re-development peak discharge rate can not exceed the predevelopment discharge rate for a single design storm event (2-year). In addition, define what type of standards to protect water quality and type of construction activities must comply with the standards. Define thresholds and standards for different types of construction activities (e.g. single family residential, large residential or commercial/industrial sites, redevelopment sites, mitigate for downstream impacts. Evaluate resource need to provide for design review, inspection and enforcement

Develop runoff conveyance performance criteria and storm sewer treatment standards. These may include the use of open swales, pocket wetlands, biofiltrations, outfall buffers, in-line stormwater treatment, and detention.

Action Item: Evaluate cost of pollution reduction strategies in various basins using pollutant-loading estimates from the Boulder Creek Watershed Study.

Implement a comprehensive stormwater pollution prevention / inspection and enforcement program. The program should address illicit connections, illegal dumping, municipal operations, household hazardous waste, and commercial/industrial pollution prevention.

Action Item: Evaluate effectiveness of existing program including implementation of programs elements implemented by other departments and agencies (Boulder County, Boulder Partners for a Clean Environment (PACE) program, Boulder Fire Department)

Implement a maintenance program to prevent and reduce pollutant runoff from the municipal storm sewer system. This may include storm sewer inlet and catch basin cleaning, street sweeping, winter road maintenance, flood control structure maintenance, and structural BMPs maintenance. Phase II regulations require an operation and maintenance program for all stormwater facilities discharging to a regulated storm sewer system. To comply, the city must provide adequate maintenance of both public system and private system, which are connected to the public system.

Action Item: Evaluate effectiveness of current maintenance practices included development of record keeping system for major maintenance activities.

Save our Streams

Implement design standards and guidelines to provide protection and enhancement of riparian and aquatic habitat and water quality.

Action Item: Determine effectiveness of existing design standards and guidelines in addressing stream bank erosion, functioning channel conditions, terrestrial habitat, groundwater/surface water interface and aquatic species movement. Greenways Design Guidelines may be appropriate document to assess.

Provide monitoring and evaluation to assess the impact of stormwater runoff on receiving waters and evaluate pollutant loading from various land-uses and pollutant sources. Identification of High Quality Water Resources: Currently, there is no method for identifying these resources.

Action Item: Evaluation the effectiveness of existing chemical and biological water quality monitoring of Boulder Creek and major outfalls and tributaries in Boulder Creek. Developed criteria to identify surface waters of high quality to prioritize application of protective and enhancement measures.